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Geographic variation within the *Hemidactylus bowringii* complex
in Myanmar and Yunnan, China.
For details see McMahan and Zug, pp. 485–509.

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# A New *Polycera* (Opisthobranchia: Mollusca) from Bahía de Banderas, México

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**A new species of dorid nudibranch of *Polycera* is described for Bahía de Banderas, along the Pacific coast of Mexico. The coloration of *Polycera kaiserae* sp. nov. is distinct from all other known species of *Polycera*. Distinctive characteristics are a pink body covered with white spots and navy blue with white tips on oral veil processes, pedal corners, branchial plumes, rhinophores, extrabranchial appendages and tail. The notum is smooth, and the radular formula and morphology are consistent with those of other species of *Polycera*. Jaws are strong with smooth masticatory edges. *Polycera kaiserae* is compared with the other six species of *Polycera* known from the eastern Pacific and with other brightly colored *Polycera* from the Indo-Pacific, Mediterranean and Atlantic.**

KEYWORDS: Polyceridae, *Polycera*, new species, Bahía de Banderas, tropical eastern-Pacific, nudibranchs.

## Resumen

**Se describe una nueva especie de *Polycera* para Bahía de Banderas, en la costa Pacífica de México. La coloración de *Polycera kaiserae* sp. nov. es distinta de cualquier otra especie de *Polycera* conocida. Sus caracteristicas difenciales son el cuerpo es rosa, cubierto de manchas blancas y con puntas azul marino y blancas en los procesos del velo oral, esquinas del pie, plumas branquiales, rinóforos, apéndices extrabranquiales y porción distal. El dorso es liso. La morfología radular es consistente con la de otros miembros de *Polycera*. La mandíbula es fuerte con los bordes masticatorios lisos. Se compara *Polycera kaiserae* con las otras seis especies de *Polycera* conocidas del Pacífico Este y con las especies de *Polycera* de coloraciones brillantes conocidas en el Indopacífico, Mediterráneo y Atlántico.**

PALABRAS CLAVE: Polyceridae, *Polycera*, especie nueva, Bahía de Banderas, Pacifico Este tropical, nudibranquios.

Altogether, four species of *Polycera* have been found in various habitats within Bahía de Banderas, Jalisco-Nayarit, Mexico (Hermosillo-González 2006). Among these, *Polycera alabe* Colier and Farmer, 1964 is known from California to Panama and displays four distinct color forms (Behrens and Hermosillo 2005); the four have been observed regularly at Bahía de Banderas, but the most common one is the form with thick orange lines, green body processes and branchial plume pink with black tips (variation B in Behrens and Hermosillo 2005); furthermore, all feed on a *Bugula* sp., a branching black bryozoan. *Polycera gnupa* (Marcus and Marcus, 1967) has a known distribution from the Gulf of California down to the Islas Galápagos, Ecuador. Only two specimens of this species have been observed in Bahía de Banderas. Thirdly, an undescribed species of a small sized *Polycera* (*Polycera* sp. in Camacho-Garcia et al. 2005) is known from Islas Revillagigedo to Islas Galápagos. When observed, it is found in clusters of multiple animals feeding on the bryozoan *Sessibugula translucens* or *Membranipora* sp.

The present paper describes a fourth, hithero undescribed species based on specimens collected eighteen months apart at two different sites in Bahía de Banderas. The first three specimens (January 11, 2006) were found at Mismaloya, a popular tourist beach located south of the town of Puerto Vallarta, at the inlet of the Mismaloya river. The substrate has large boulders, small turnable rubble and a muddy sand bottom, with a steep profile. The second two specimens (June 12, 2007) were found at El Morro, which is an islet located outside the mouth of the bay close to the marine park of Islas Marietas. The most notable characteristic of El Morro is a through-and-through sea cave at a depth of about 30 meters. The opisthobranch fauna observed inside the cave is similar to the one observed at another large cave located on one of the Islas Marietas. The species composition found inside the cave is remarkably different from other sites studied in the bay (Hermosillo-González, 2006). The specimens were found at some 10 meters into this cave.

## MATERIALS AND METHODS

The material examined is deposited at the Department of Invertebrate Zoology and Geology of the California Academy of Sciences, San Francisco (CASIZ) and the Malacology Section of the Natural History Museum of Los Angeles County (LACM). Specimens were dissected and the internal features were examined and drawn using a dissecting microscope with a camera lucida. The penis was dissected and dried with 1,1,1,3,3,3-hexamethyldisilazane for Scanning Electron Microscopy (SEM). The buccal mass was removed and dissolved in 10% sodium hydroxide until the radula was isolated from the surrounding tissue. The radula was then rinsed in water, dried, and mounted for examination with the SEM.

Features of living animals were recorded in the field by digital photography, both *in situ* and in aquarium photographs. On the first occasion, an Olympus 770 digital camera was used, with an Olympus housing and an INON slave strobe. The second time, a Nikon Coolpix 995 camera, with a YS-90 Sea and Sea and a slave strobe INON, was used. Neither color correction was used nor were the photographs modified in Photoshop.

## SPECIES DESCRIPTION

### Family Polyceridae Alder and Hancock, 1845; Bergh, 1891

### Genus *Polycera* Cuvier, 1817

### *Polycera kaiserae* Hermosillo and Valdés, sp. nov

Figures 1A, B and C.

SYNOPSIS OF *POLYCERA*.— Body limaciform, notum smooth, papillate or tuberculate; veil with digitate or tuberculate papillae, nonretractile rhinophores, perfoliate clavus, one or more extrabranchial papillae on either side of the branchia, pinnate gill in semicircle around the anus. Gill not retractable into gill pocket. Paired jaws with or without a large wing-like extension. Radula with no rachidian tooth, inner laterals hamate, outer laterals simple plates. Large prostrate gland, glans penis armed with spines.

MATERIAL EXAMINED.— HOLOTYPE: El Morro (20°41.253′N 105°39.913′W), Bahía de Banderas, Jalisco-Nayarit, México, 12 June, 2007, 1 specimen preserved length 11 mm, collected inside a sea cave at 30

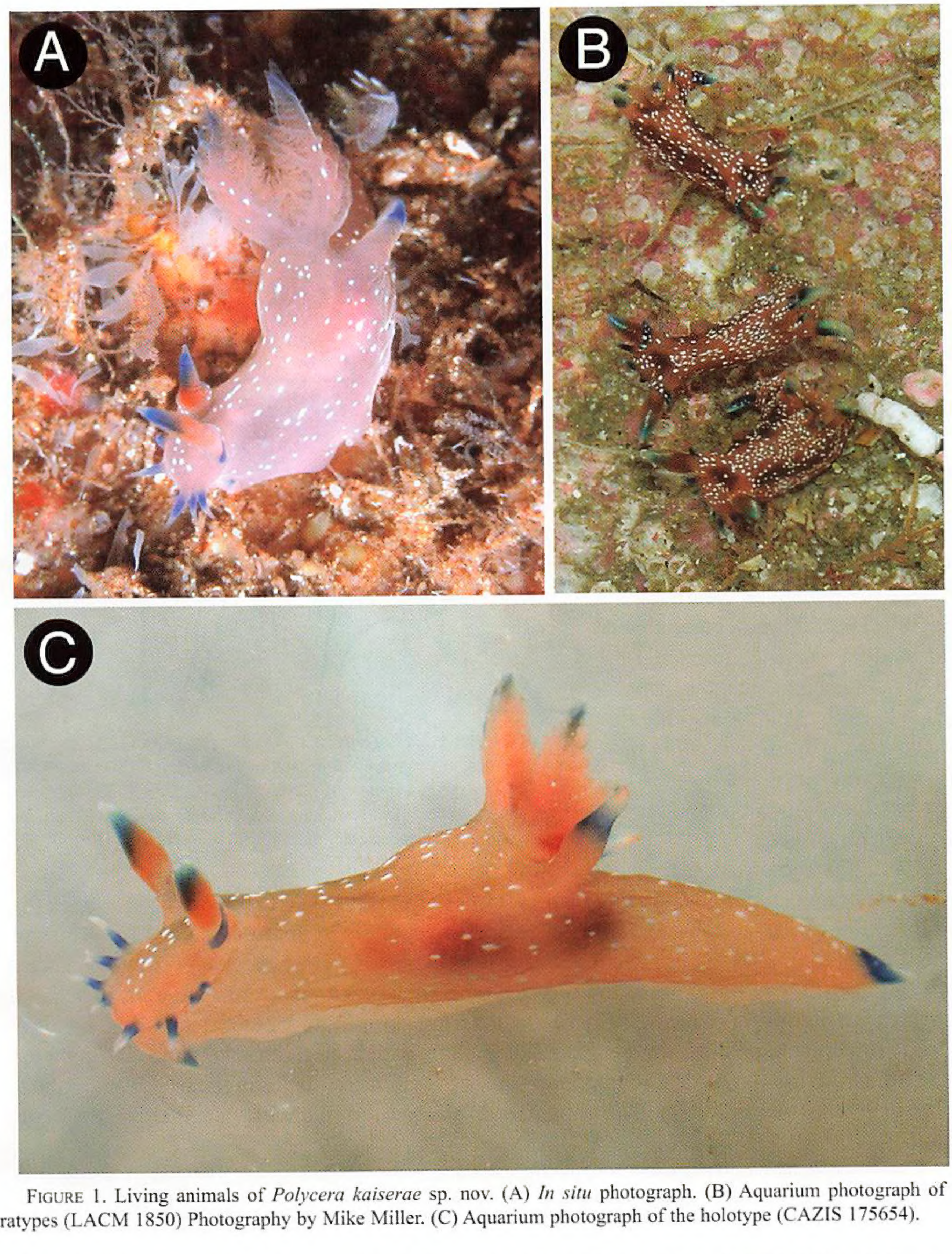

FIGURE 1. Living animals of *Polycera kaiserae* sp. nov. (A) *In situ* photograph. (B) Aquarium photograph of the paratypes (LACM 1850) Photography by Mike Miller. (C) Aquarium photograph of the holotype (CAZIS 175654).

m of depth (CAZIS 175654). PARATYPES (3): Mismaloya (20°31.937′N, 105°17.700′W) Bahía de Banderas, Jalisco-Nayarit, México, 11 January, 2006, 3 specimens collected on rocks and rubble at 11 m of depth, preserved length is 5 mm (LACM 1850).

**EXTERNAL MORPHOLOGY.**— The maximum length of the living animals was 24 mm (holotype). The preserved holotype measures 11 mm long and 3 mm wide, the length of the three paratypes is 5 mm. The morphology of the body is typical of *Polycera*. The body is elongated and spindle shaped when fully extended. The widest and highest part of the body is located at the level of the branchial plume and extra branchial processes. It is compressed laterally and highly arched in the branchial region. Posterior to the gill, the body tapers rapidly to a sharply pointed posterior end of the foot. There is a distinctive mid-dorsal cardiac prominence just anterior to the gill. The foot is simple, with pointed pedal corners (Fig. 2C). There is no marked caudal ridge.

The velar processes or papillae are conical in shape with a point tip, numbering six to eight in the five specimens examined (Fig 2C). The velar processes are held straight out and horizontal and are of unequal lengths. On each side of the veil the papillae are about equally spaced, with a larger gap between the frontalmost papillae, which are shorter than the lateral ones.

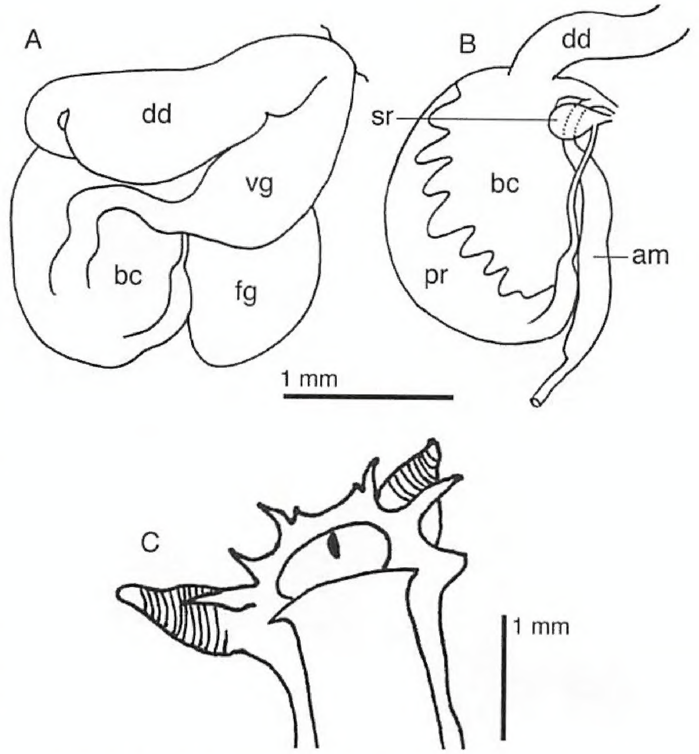

FIGURE 2. *Polycera kaiserae* sp. nov., anatomy. (A) and (B) Reproductive system and detail of reproductive organs of the paratype (LACM 1850). (C) Ventral view of cephalic region of the holotype (CAZIS 175654). Abbreviations: am, ampulla; bc, bursa copulatrix; dd, deferent duct; fg, female glands; pr, prostate; sr, seminal receptacle; vg, vagina.

The gill is composed of five unipinnate branchial plumes, the three anterior ones are longer than the two posterior ones (4–1.9 mm long), they form a semi-closed circle, with an open angle of approximately 120°. The anus is located in the middle of the branchial plume. There is one extra branchial appendage on each side of the gill; positioned posterior to the forward most plume and parallel to the middle pair. These processes are digitiform, wide at the base and tapering abruptly to a blunt tip.

The rhinophores of the holotype have 22 lamellae, with a short terminal knob. The total length of the rhinphore is 3.7 mm. The rhinophoral sheath is cylindrical, taller in the back than in the front (1.7 and 0.9 mm respectively). The rhinophores are located relatively far apart in the cephalic region.

The color of the body varies from a light pink in the larger specimens (Fig. 1A and C) to a darker pink in the smaller ones (Fig. 1B). It is sprinkled with numerous opaque white irregularly shaped spots on the dorsum, cephalic region, rhinophoral sheats and gill plumes. These spots are denser on the smaller specimens, giving them a frosted appearance. The most distinctive external feature of this species is the coloration scheme on gill plumes, extra branchial processes, foot, rhinophores, pedal corners, rim of rhinophoral sheath and velar processes. Proximally, all these processes are the same color as the body; the distal half is navy blue with a white or off-white tip.

**INTERNAL ANATOMY.**— The buccal mass is muscular with a small radular sac and two salivary glands attached at the sides of the esophageal connection.

The radular formula is 11 x 2.1.1.0.1.1.2 for one of the paratypes (12 mm long specimen LACM 1850). There are no rachidian teeth. The innermost lateral teeth are hamate with a strong, triangular cusp and a smaller, secondary cusp about mid-length (Fig 3A). The second lateral teeth are also hamate and have a wing-like extension near the base. The outer teeth are two small, simple plates per row, lacking denticles.

The labial cuticle has a pair of jaws with smooth masticatory edges (Fig. 3B). The shape of the jaw is almost rectangular with a pointy lateral expansion.

**Reproductive system.**— The description of the reproductive system is based on sexually mature animals (Figs. 2A–B, 3C–D).

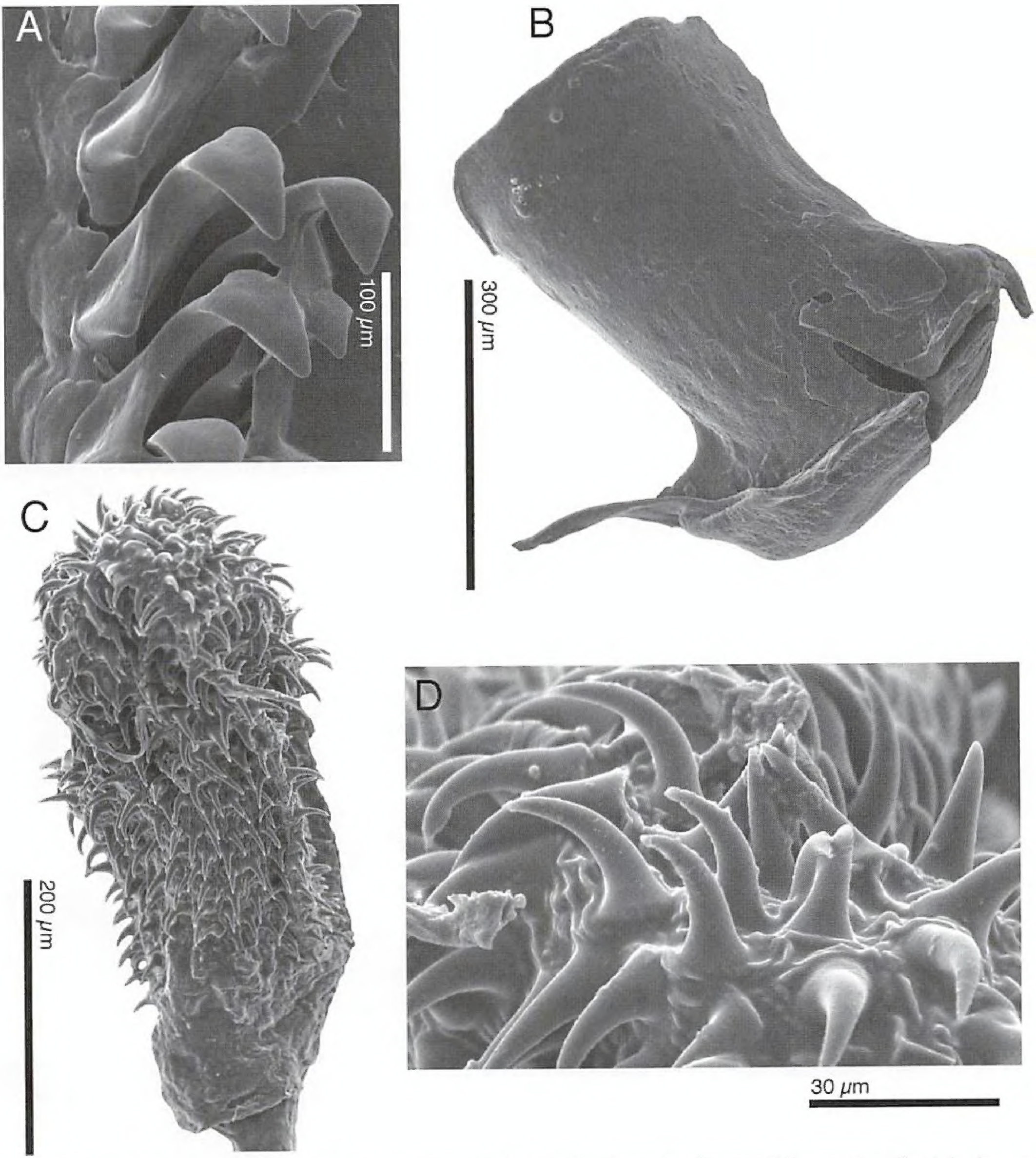

Figure 3. *Polycera kaiserae* sp. nov., paratype (LACM 1850), Scanning Electron Micrographs of radula, jaws and penis. (A) Lateral and marginal teeth. (B) Jaw. (C) Everted penis. (D) Detail of the spines on penis.

The genital opening is located in the right side of the body, posterior to the rhinophores; in the living animals it is observed as a dark spot. Within the genital opening a vestibule is observed where distal portions of the vagina and deferent duct are located. Both are tubular enlarged structures of about the same size. The vagina then tapers and empties into the bursa copulatrix through an irregular duct (Fig. 2A). The bursa copulatrix is oval and large. The deferent duct folds back on itself, tapers and connects into the prostate, which partially envelops the bursa copulatrix and is about half its size (Fig. 2B). The ampulla leads forward and inserts through a branched narrow duct into the deferent duct and prostate connection. The ampulla is long and regularly shaped, tapering at both ends. The pyriform seminal receptaculum is connected to the bursa copulatrix through a long and narrow duct. The penis is armed, the complete surface covered with densely set hamate spines. These spines are equal in size and directed back toward the base of the penis when the penis is everted (Figs. 3C and D).

**GEOGRAPHIC RANGE.**— This species has only been collected in Bahía de Banderas, Jalisco-Nayarit.

**NATURAL HISTORY.**— *Polycera kaiserae* has been observed three times, once at 11 m of depth on a coastal rocky shore near a river inlet; there were three specimens close together. The second time, on a far-from-shore islet, two specimens were observed inside a sea cave at a depth of 30 m. The third time, it was seen on a coastal rocky shore area at a depth of 7 m. On all occasions, animals were observed feeding on a clear-colored, branching bryozoan. One egg mass was observed with the three specimens, a typical dorid ruffled spiral, rose pink, laid on the bryozoan (Fig. 1A).

**ETYMOLOGY.**— The specific name *kaiserae* is given in recognition of our dear friend Kirstie Kaiser. Her dedication has contributed greatly to our knowledge of the molluscan fauna of the eastern Pacific and her upbeat outlook has made our field work more fun and productive.

**REMARKS.**— *Polycera kaiserae* has all the features characteristic of the genus *Polycera* as follows: body limaciform, notum smooth; veil with digitate pointed, non-retractile rhinophores, perfoliate clavus, extrabranchial appendages on either side of the gill plume; pinnate branchia in semi-closed circle around the anus with five leafs (although some other species of *Polycera* have different numbers). Gill non-retractable. Paired jaws with or without a large wing-like extension. Radula without a rachidian tooth, similarly-sized inner laterals hamate, outer laterals simple plates. Large prostrate gland, glans penis armed with spines.

No species of *Polycera* resembles the striking external coloration of *Polycera kaiserae*: pink body covered by white spots and navy blue with white tips on oral veil processes, pedal corners, branchial plumes, rhinophores, extrabranchial appendages and tail. Nevertheless, it should be compared with the other six species of *Polycera* known for the eastern Pacific: *Polycera alabe* Colier and Farmer, 1964, *Polycera atra* MacFarland, 1905, *Polycera gnupa* (Marcus and Marcus, 1967), *Polycera hedgpethi* Marcus, 1964, *Polycera tricolor* Robilliard, 1971, and *Polycera* sp. Only three of these, *Polycera alabe*, *P. gnupa*, and *Polycera* sp. overlap the known distribution of *Polycera kaiserae*.

*Polycera alabe* exhibits a wide variation in its coloration, but it consistenly has green or dark processes, as well as yellow lines and spots on a dark brown or black body (Behrens and Hermosillo 2005); *Polycera atra* has black longitudinal stripes on a white or gray body, with yellow spots all over the body (Robilliard 1971); *Polycera gnupa* has a gray-brown mottled body, with a yellow and blue or green ring on the distal portion of the oral veil processes and extrabranchial appendages (Marcus and Marcus 1967); *Polycera hedgpethi* has a brownish coloration that varies in shade with two white longitudinal lines, the oral veil processes, extrabranchial appendages and tail are white colored with yellow on the distal third; the branchial plume is dark brown (Miller 2001). *Polycera tricolor* has a barely translucent white body, tips of rhinophores, veil papillae, and extrabranchial processes, a yellow line around the edge of the foot, and the gill plumes, extrabranchial processes, rhinophores and veil processes are proximally black and distally yellow (Robilliard 1971). In an undescribed species from the tropical Eastern Pacific (*Polycera* sp. Camacho-Garcia et al. 2005), the body color is black, with bronze colored papillae and orange lines or dots along the body. The rhinophores, oral veil processes, foot, and extrabranchial appendages are light green (Camacho-Garcia et al. 2005).

The notum of *Polycera kaiserae* is smooth; this is also true for *Polycera tricolor*, whereas the other five eastern Pacific species present varying degrees of papillae and tubercles. Five species have more than one pair of extrabranchial processes, whereas *Polycera kaiserae* has one pair and *Polycera alabe* lacks these altogether (Robilliard 1971).

There are other colorful species of *Polycera*, but none of them resembles the external coloration of *Polycera kaiserae*. Examples include *Polycera chilluna* Er. Marcus, 1961, from the eastern Atlantic and Caribbean, which has a grayish body with longitudinal yellow lines and appendages (Valdés et al. 2006), and *Polycera incognita* (Ortea, Espinosa, and Caballer, 2004), also from the Caribbean, which is reddish brown, with black spots and white appendages, and the body is tuberculate (Valdés et al. 2006). Indo-Pacific examples include *Polycera abei* Baba, 1960, that is bright orange with black spots and appendages (Baba 1960); *Polycera maddoxi* Miller, 2005, is dark maroon with yellow spots (Miller 2005); *Polycera janjukia* Burn, 1962, is purple with yellow spots and appendages (Miller 2005); *Polycera parvula* (Burn, 1958), known from Australia, is reddish orange with yellow spots (Miller 2005); and *Polycera capensis* Quoy and Gaimard, 1824, known from South Africa and Australia, has bright white with black longitudinal lines with yellow appendages and velar processes (Gosliner 1987). Brightly colored species from the Eastern Atlantic include *Polycera faeroensis* Lemche, 1929, from the north-eastern Atlantic, has a white body with yellow appendages (Picton and Morrow 1994), and *Polycera quadrilineata* (Muller, 1776), which is white with speckled with orange or red, is known in Europe, from Greenland to the Mediterranean, and South Africa (Gosliner 1987). *Polycera elegans* (Bergh, 1894), known from the Atlantic and Mediterranean, has a bright orange body with scattered iridescent blue oval spots and gill branches with white longitudinal lines (as *Grielada elegans* in Picton and Morrow 1994).

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Roberto Chavez and Buceo Vallartech, Puerto Vallarta, Mexico provided support for the field work. We thank Mike Miller for diving with us and photographing specimens in the field. Two anonymous reviewers provided constructive criticisms on the manuscript. This paper is part of the National Science Foundation-supported project "Phylogenetic Systematics of Nudibranchia," funded through PEET grant DEB-0329054 to Terrence M. Gosliner and the junior author. The SEM work was conducted at the Natural History Museum of Los Angeles County, supported by the National Science Foundation under MRI grant DBI-0216506 to the junior author and collaborators.

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# Burmese *Hemidactylus* (Reptilia, Squamata, Gekkonidae): Geographic Variation in the Morphology of *Hemidactylus bowringii* in Myanmar and Yunnan, China

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**Six species of the gecko genus *Hemidactylus* are reported currently from Myanmar. This genus, in the family Gekkonidae, is the most geographically widespread and one of the most speciose. Morphological analysis within one Burmese species, *H. bowringii*, is concordant with the geographic pattern of genetic differentiation revealed by Carranza's and Arnold's (2006) phylogram based on mtDNA sequence data. Our analysis shows additional foci of regional differentiation within Burmese *H. bowringii* at other localities not included in the aforementioned phylogeny. The regional differentiation among the populations examined indicates that two species occur in central and northern Myanmar. One species occurs across northern Myanmar from Sagaing and Kachin into western China and southward east of the Ayeyarwady River to at least the Bago-Mandalay division border; the southern species occurs from west of the Ayeyarwady River from central Magway to Yangon. Neither of these two populations appears conspecific with Hong Kong *H. bowringii* (type-locality), hence each is recognized as a new species. *Hemidactylus bowringii* proper is the species occurring in South China. The status of *Hemidactylus berdmorei* (Blyth, 1853), an assumed synonym of *H. bowringii*, of southern Tanintharyi remains unresolved.**

Myanmar (Burma) hosts six species of *Hemidactylus* geckos. This genus is among the most speciose of the gekkonids (~85 known species), as well as the most widely distributed gecko genus (Kluge 2001). Morphologically, *Hemidactylus* geckos are united by derived traits in toe morphology. These traits include varying numbers and degrees of divisions in lamellae of the manus and pes (Boulenger 1885). However, there is also sizeable variation among species in traits such as head proportions, body and limb size, and scalation patterns (Loveridge 1947; Smith 1935); nevertheless, the unique aspects of foot morphology reflect the monophyly of *Hemidactylus*. This monophyly was recently confirmed by mtDNA sequence analysis of 33 *Hemidactylus* taxa from more than 90 localities throughout the worldwide distribution of this genus (Carranza and Arnold 2006). Their study showed that *Hemidactylus* consisted of five clades, one of which contained all tropical Asian species. They further demonstrated that Burmese populations of *H. bowringii* and *H. brookii* each consist of more than a single genetic lineage (Fig. 1).

The presence of multiple genetic lineages within supposed single species suggests hidden biodiversity within the known and seemingly morphological uniform Burmese species. This seeming uniformity, however, has not been examined closely in any of the Burmese *Hemidactylus* or for that matter in any tropical Asian *Hemidactylus*. Our goal was two-fold, first to test the assumed uniformity in Burmese *H. bowringii*, which is well represented by vouchers of the joint CAS-NWCD-SI Myanmar Herpetofaunal Survey. We examined the external morphology of Burmese populations for regional differentiation. If regional differentiation exists, our second goal was to determine the degree of concordance between the observed regional morphological differentiation and the genetic lineages revealed by Carranza's and Arnold's mtDNA analysis.

## MATERIALS AND METHODS

Our study focused on samples of *Hemidactylus bowringii* from throughout Myanmar and an adjacent locality in Yunnan, China. The specimen localities lie between ~26° and 17°N and at elevations from 5 to 1000 m. The distribution of the Myanmar *H. bowringii*-like geckos is depicted in Zug et al. (2007, fig. 1). For this study, we organized the specimens into two sampling sets: 1) locality samples, based largely on state or division of the specimens' origins; and 2) latitudinal samples by the latitude (rounded to the nearest integer) of the specimens. The total number of Burmese-Yunnan specimens examined is 108 individuals; they are identified in Appendix B, therein organized by locality sample. The numeric composition of the two sample sets is depicted in Table 1.

Our preliminary examination for morphological differences between geographically distinct individuals from Yunnan (Southwest China) and Shwe-Settaw (west of the Ayeyarwady River in Magway Division) identified no striking scalation differences. However, a possible difference in body size and head proportions was recognized. From this initial comparison and examination of current gekkonid literature, we developed a set of 12 mensural and 13 meristic (scalation) character traits. Most traits were adapted from Zug et al, 2003. Definitions of these traits are presented in Appendix A. Each trait has a unique abbreviation for ease of recognition of the traits within the text, tables, and figures of this report. Each specimen was dissected to examine the gonads to determine sex and maturity. Females were considered mature when they possessed vitellogenic follicles, typically >1.5 mm diameter, oviducal eggs, or stretched oviducts; males were recorded as mature when testes and epididymides were enlarged, supplemented by presence of secreting precloacal pores.

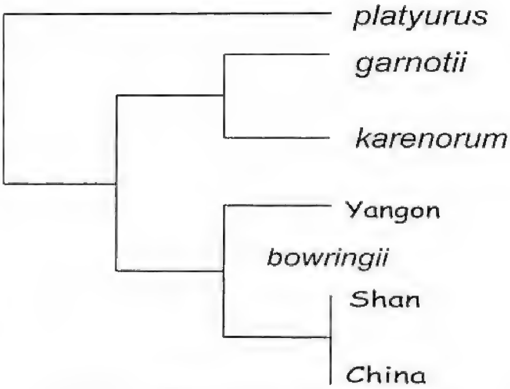


FIGURE 1. Stylized dendrogram displaying the proposed relationships among the Burmese members of the *Hemidactylus bowringii* species complex (*fide* Zug et al. 2007). The dendrogram derives from the maximum likelihood tree of Carranza and Arnold (2006: fig. 1). Tissue vouchers from the CAS-NWCD-SI survey are: *platyurus* CAS 204982, 215451, 222332; *garnotii* CAS 184322–323, 21059, 210280, 213517; *karenorum* CAS 210670; *bowringii* Yangon CAS 213333, Shan CAS 216345 [from Shan-Mandalay border, included in the Mandalay locality sample for this study], China (Yunnan) CAS 207483.

TABLE 1. Composition and coding of the two sets of the Burmese-western Chinese *Hemidactylus bowringii* samples. Localities arranged roughly north to south. Sample size, *n*. The names are used in the text and the codes in the figures to designate specific samples.

| Sample | *n* | code | Sample | *n* | code |
|---|---|---|---|---|---|
| Yunnan | 16 | C | 27° | 5 | 7 |
| Kachin | 16 | K | 26° | 16 | C |
| Sagaing | 18 | A | 25° | 11 | 5 |
| Shin-Ma-Taung | 7 | T | 24° | 7 | 4 |
| Mandalay | 19 | M | 23° | 4 | 3 |
| Shwe-Settaw | 28 | S | 22° | 16 | 2 |
| Yangon | 4 | Y | 21° | 17 | 1 |
| | | | 20° | 28 | 0 |
| | | | 17° | 4 | Y |

SYSAT version 11 was used for all statistical analyses. Central-tendency statistics provided the baseline analysis. Dimorphism between adult females and males was examined by Student's *t* test and identified with a $p \leq 0.05$ in the pooled-variance *t* test. The larger variance pool aids confidence in accepting or rejecting dimorphism in samples comprised of smaller sample sizes and/or an inequality of females-males. We use principal components analysis (PCA) and discriminant function analyses (DFA) to examine the distribution of individuals and samples within multi-character space as well as the relationships of the samples to one another. To enhance this examination, our PCA and DFA compare the mensural and meristic (scalation) character sets separately and the two sexes separately. None of the data sets is transformed; for PCA, we use correlation matrices, no axis rotation, and principal components scores. Both multivariate protocols serve in an exploratory manner to examine intersample character variation and to test for potential differentiation among the samples.

## OBSERVATIONS OF MORPHOLOGICAL VARIATION IN BURMESE-YUNNAN *HEMIDACTYLUS BOWRINGII*

**SEXUAL DIMORPHISM.**— Few of the individual locality samples are sufficiently large to provide a robust test of dimorphism between females and males. The samples that we consider adequate to test (Table 2) reveal little evidence of dimorphism between the sexes. None of the tests suggests an overall size (SVL) differential of the two sexes within any sample. Body segment measurements show dimorphism in only two samples. The latitudinal 21° sample has males with statistically thicker heads (HeadH) and longer neck-head lengths (SnForeL). Mandalay males had longer EyeEar and CrusL than females.

Dimorphism is not evident in any scalation trait other than TotPore, with a single exception. All males have pores. All females lack secreting pores, and only a few females have some "pore-scales" with dimples but without evidence of a secretion beneath the dimple. Sagaing shows significant differences in all four digit traits (Table 2). Although this dimorphism might be real, the fractional difference in means of the two sexes and the unequal number of males and females suggest a stochastic event. None of the other traits in the Sagaing sample approaches significance.

TABLE 2. Summary of dimorphism in adult *Hemidactylus bowringii* of the Burmese-western Chinese samples. Character abbreviations defined in Appendix A; localities arranged roughly north to south. Results presented for samples with $n>12$ and/or one sex $n \geq 4$; sample size in parentheses – females, males.

| | Mensural: | Scalation: |
|---|---|---|
| Yunnan & 26° (9♀, 5♂) | No dimorphism | Inflab, TotPore |
| Kachin (4♀, 12♂) | No dimorphism | TotPore |
| 25° (4♀, 7♂) | No dimorphism | TotPore |
| Sagaing (10♀, 5♂) | No dimorphism | TotPore, 4FingLm, 4FingDv, 4ToeLm, 4ToeDv |
| 21° (9♀, 8♂) | HeadH, SnForelL | TotPore |
| Mandalay (10♀, 8♂) | EyeEar, CrusL | TotPore |
| Shwe-Settaw & 20° (14♀, 14♂) | No dimorphism | TotPore |

**MENSURAL TRAITS.**— Three locality (Kachin, Sagaing, Mandalay) and three latitudinal (21°, 22°, 25°) samples are geographic composites (see Appendix B). These composite samples encompass broad geographic areas, hence it was necessary to address whether each composite represented a single population [in the broadest sense]. Our assumption is that if multiple populations (genetic lineages) are represented in a single locality sample, the means of several characters should be significantly different and/or the variance of several characters should be greater in composite samples compared to those traits in samples derived from a single geographic site. Because of the relatively small sizes of our composite samples, a few characters by chance can be expected to show differences, and occasionally as statistically significant. We tested difference in means with Student's $t$ tests and the equality of character variance by visual comparison of the Coefficients of Variation ($V$). These tests were applied to both mensural and scalation characters, and where one or both suggests multiple populations, the mixed nature of sample is discussed within this section.

Intrasample comparison of the three composite locality samples indicates that each represents a single population. Neither Mandalay nor Sagaing has any mensural or scalation traits displaying significant differences ($p \leq 0.05$ for Student's $t$ tests) among the multiple localities. Kachin has one to three traits with statistically significant $t$ values in the three pair-wise analyses. Only EyeEar is common between two localities. Further, the $V$s of Kachin's measurements equal or are less than those of Yunnan, in which all individuals derived from the walls of a single hotel in Liuku. This discordance of only a few characters supports the interpretation that the Kachin sample represents a single population. The three sites (Appendix B) comprising this sample are a maximum of 230 km distant on a N-S axis. For comparison the most distant sites for Mandalay and Sagaing are each about 300 km apart. Two of the composite latitudinal samples (25°, 22°) have one (NarEye) or no traits with significant differences. In contrast, the 21° sample displays major differences for most mensural and scalation traits between the sites east of the Ayeyarwady River and a single site (Shin-Ma-Taung) west of the river, clearly demonstrating that this composite represents two distinct populations. These differences will be identified later in the appropriate sections.

The Burmese-Yunnan *Hemidactylus bowringii* are not large geckos. Their mean body sizes range from 49.1 mm (Yunnan) to 37.5 mm SVL (Shwe-Settaw). Other mensural traits (Table 3) have moderate to high association with overall body length. Correlation is greatest with long-axis measurements, such as TrunkL ($r$ = 0.82), SnForel (0.87), HeadL (0.79), SnEye (0.80), and least

TABLE 3. Summary of select mensural traits in adults of the Burmese-western Chinese *Hemidactylus bowringii* samples. Character abbreviations are defined in Appendix A. Sample sizes are in parentheses. All measurements are in mm: mean ± $s$, minimum and maximum values.

| Sample | SVL | TrunkL | SnForel | HeadL | JawW | SnEye | ForeaL | CrusL |
|---|---|---|---|---|---|---|---|---|
| Yunnan (16) | 49.1±3.32 | 24.0±2.11 | 17.3±1.31 | 12.1±0.81 | 7.2±0.55 | 5.0±0.39 | 5.8±0.53 | 6.4±0.29 |
| [also 26°] | 43.7–56.3 | 18.6–27.4 | 14.2–19.0 | 10.9–13.6 | 6.2–8.0 | 4.4–5.6 | 4.9–6.5 | 5.8–7.0 |
| Kachin (16) | 49.0±3.32 | 23.3±2.12 | 19.0±1.73 | 12.1±0.73 | 7.4±0.42 | 5.2±0.33 | 5.9±0.41 | 6.7±0.34 |
| | 45.0–53.2 | 20.3–27.4 | 16.7–22.6 | 10.7–13.3 | 6.8–8.4 | 4.6–6.1 | 5.2–6.5 | 6.1–7.5 |
| 25° (11) | 48.3±2.40 | 23.6±1.99 | 18.3±1.28 | 11.8±0.69 | 7.3±0.36 | 5.1±0.23 | 5.9±0.37 | 6.7±0.21 |
| | 45.0–51.6 | 20.3–27.4 | 16.7–20.4 | 10.7–12.9 | 6.8–7.8 | 4.6–5.4 | 5.2–6.4 | 6.3–7.0 |
| Sagaing (18) | 43.8±2.99 | 20.7±2.10 | 16.0±1.33 | 11.0±0.68 | 7.0±0.47 | 4.6±0.33 | 5.2±0.54 | 5.8±0.68 |
| | 39.7–50.7 | 16.9–25.6 | 13.7–17.8 | 9.9–12.4 | 6.1–8.0 | 4.1–5.1 | 4.4–6.4 | 5.0–7.1 |
| 22° (14) | 45.6±3.44 | 21.4±1.68 | 16.8±1.16 | 11.2±0.68 | 7.1±0.53 | 4.7±0.39 | 5.7±0.58 | 6.4±0.70 |
| | 39.7–51.4 | 18.8–25.6 | 14.9–19.1 | 9.9–12.4 | 6.1–8.0 | 4.1–5.4 | 4.9–6.7 | 5.4–7.6 |
| Shin-Ma-Taung (7) | 41.1±1.99 | 19.0±1.70 | 15.9±1.20 | 10.2±0.54 | 8.9±1.67 | 4.1±0.31 | 4.5±0.33 | 5.1±0.46 |
| | 37.2–43.9 | 16.3–20.5 | 13.6–17.4 | 9.4–10.8 | 6.8–10.7 | 3.7–4.7 | 3.9–4.9 | 4.3–5.7 |
| Mandalay (18) | 47.3±2.72 | 21.5±1.68 | 17.7±1.02 | 11.6±0.76 | 7.0±0.54 | 4.8±0.39 | 6.0±0.35 | 6.9±0.49 |
| | 40.6–51.9 | 18.8–24.6 | 15.9–19.9 | 10.2–13.4 | 5.8–7.8 | 3.9–5.4 | 5.4–6.7 | 6.1–8.0 |
| Shwe-Settaw (28) | 37.5±2.10 | 16.6±1.43 | 14.1±0.91 | 9.4±0.74 | 5.9±0.38 | 3.7±0.24 | 4.5±0.35 | 5.0±0.45 |
| [also 20°] | 34.4–43.3 | 13.9–19.9 | 12.5–16.0 | 8.3–11.0 | 4.9–6.9 | 3.4–4.4 | 3.8–5.2 | 4.0–5.8 |
| Yangon (4) | 38.1±2.65 | 17.1±1.17 | 15.1±1.27 | 9.7±1.02 | 6.1±0.49 | 3.9±0.31 | 4.7±0.29 | 5.5±0.61 |
| | 35.7–41.6 | 16.1–18.8 | 13.4–16.3 | 8.8–11.1 | 5.5–6.7 | 3.6–4.3 | 4.4–5.1 | 5.0–6.4 |

for JawW (0.42). The preceding pattern from the Mandalay sample is matched in the other larger samples (Yunnan, Kachin, Shwe-Settaw). The similarity in correlations among the four largest locality and two largest latitudinal (22°, 25°) samples is also displayed in their normal levels of variation. All show *V*s ranging between 3–10% for all measurements except NarEye and SnW. Usually (>75%), the *V*s are ≤8% including the latter two measurements. These data are consistent with the interpretation that only the 21° sample is mixed, i.e., contains representatives of two distinct populations.

The trend, evident from visual examination of the data (Table 3), is the largest adults occur in the more northerly and/or mountainous localities (> 48 mm mean SVL; Yunnan, Kachin, 25°). Average body size declines southward with the smallest *H. bowringii* in Shwe-Settaw and Yangon. Ranges of body sizes overlap in adjacent samples, but 24° (Chatthin Wildlife Sanctuary) adults average 42.2 mm SVL (39.8–43.7 mm, *n* =5), not overlapping with the more northerly ones. The Sagaing sample (containing the Chatthin [22°N] specimens) overlaps with the northern samples as do the 22° and Mandalay ones. Shin-Ma-Taung barely overlaps with Yunnan, and Shwe-Settaw and Yangon have no overlap with Yunnan. Maturity is attained at a smaller SVL (~35 mm) in the southern population on the west side of the Ayeyarwady River. The Mandalay sample (east of Ayeyarwady) has a minimum size of maturity at 40.6 mm SVL. Owing to the association of the other measurements with SVL, the preceding pattern is displayed similarly in each of those traits.

Examining the measurements and samples in multidimensional space reveals a similar, although somewhat more revealing, pattern of geographic differentiation. We have maximized the exploratory aspect of DFA and PCA by the examination of adults only and females and males separately. SnW is excluded from these analyses owing to measuring difference of the two authors.

PCA and DFA identify different sets of "significant" traits, i.e., those accounting for variance in PCA and those contributing to group discrimination in DFA. The PCA sets are similar for adult females and males. All measurements except JawW load strongly on the first component (PC1) in females and roughly equally. This loading of the first 10 measurements declines slowly with a distinct drop in loading value for JawW. SVL, HeadL, and SnEye are the three highest loading traits (i.e., 0.96–0.98) on the females' first component; JawW is the major loading trait for PC2 and all others of minor weight. The same three traits form the top loading cluster in males with nearly identical loading values; subsequent loading value and position are somewhat, but not greatly, different, and again JawW has the lowest loading with a distinct gap from the other 11 traits. JawW is again the major loading trait for PC2.

The DFA sets for females and males share a single character (JawW) strongly influencing the discrimination function (i.e., high F-to-remove values). For females, TrunkL and NarEye also are significant traits, but only the CrusL in males. After these three and two traits, respectively, trait influence in discrimination drops sharply. The resulting classification matrices display similar results. Examining only the results of the Jackknife classifications, China (Yunnan) females are 100% correctly classified, Shwe-Settaw 73%, Yangon 67%, and Mandalay and Shin-Ma-Taung 60%; the mean classification for the seven samples is 65%, see Fig. 2; for males, accuracy of classification is Shwe-Settaw 79%, Mandalay 63%, and all others are at or below 50% (mean 55%). Classification accuracy is considerably higher (means 88 and 85%, respectively) in the nonjackknived matrices.

The misclassifications are informative by their suggestion of regional relationships. For females, Shwe-Settaw misclassified individuals were assigned to Yangon and Sagaing; Mandalay's broadly to China, Kachin, Sagaing, and Shwe-Settaw; Shin-Ma-Taung to Sagaing; Sagaing's also broadly to Kachin, Mandalay, Shwe-Settaw, and Yangon; Kachin's to China and Sagaing; and Yangon's to Shwe-Settaw. For males, Shwe-Settaw misclassified individuals were placed in Yangon and Sagaing; Mandalay's misclassified in Kachin and Yangon; China's in Kachin; Shin-Ma-Taung's in Sagaing; Sagaing's in Kachin and Shwe-Settaw; and Kachin's in China, Sagaing, and Mandalay. The single Yangon male was assigned to the Sagaing group. The relative distribution or relationship of the individuals is depicted in Fig. 2.

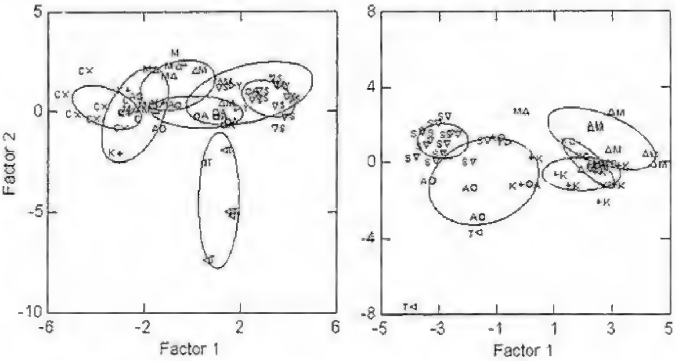


FIGURE 2. DFA canonical scores plots for mensural data of adult females (left) and males (right) of the *Hemidactylus bowringii* locality samples. The ellipses define the 50% probability limits of each sample locality; capital letters denote locality and are identified in Table 1

A DFA examination of the latitudinal samples of adult males and females did not reveal a drastically different pattern from the DFAs of the regional samples, although a considerably lower level of overall accuracy (48%). The lessening of accuracy results from an increase in samples and a concomitant reduction in their sample sizes, i.e., latitudinal 19° (*n* = 1) sample misclassified, accuracy 0%, and also the number of samples (10) nearly equals the number of traits (11) in the model. Nevertheless, the results show some regional robustness: 25° (=Chatthin W.S.) has 100% accuracy; and 20° (Shwe-Settaw) and 26° (China) each displays 70% accuracy. Again, Shwe-Settaw's misclassifications are Yangon (17°) assignments, and China's with Kachin (25°, 27°). Sample 21° misclassifications (21% accuracy) are to latitudinal samples to the north (22°–26°).

**Meristic traits**— Of the 13 scalation traits recorded, no sample displays a unique aspect of scalation, i.e., unique in the sense there is no or minimal overlap of one or a set of traits among localities. All traits have either broad overlap or near identity of ranges of values (see Table 4). Although overlap occurs, some trends can be observed, usually with a slight reduction in means from north to south. All populations contain individuals with three SnS, two large scales on each side abutting the nasal scale and a variable-sized median scale; Mandalay and southern samples (Shin-Ma-Taung, Shwe-Settaw) have numerous individuals without a median scale. In most Burmese *H. bowringii*, the first infralabial scale has a triangular extension that touches the naris/nasal scale (NaInf). Southern populations have numerous individuals in which the extension does not reach the nasal scale. For the Suplab, there is a slight reduction from north to south. A reduction trend is not evident in the Inflab. In most *H. bowringii*, the first pair of chin scales is large and broadly in contact on the midline behind the mental scale; however, some individuals in the China and Yangon samples have smaller scales and no medial contact. TotPore (males only) shows a distinct north-south cline with fewer pores in the southern samples. The number of finger and toe lamellae (4FingLm, 4ToeLm) is nearly uniform in all samples except Shin-Ma-Taung. These characters are examined in more detail later in this section.

Unlike in the mensural characters, PCA and DFA identify overlapping sets of "significant" scalation traits. The PCA sets are nearly identical for adult females and males. For females, component loading (PC1) is highest for 4ToeDv; 4FingLm, Suplab, 4FingDv, and 4ToeLm (in order of decreasing loading; 0.84 to 0.70) and in males, 4ToeDv; 4FingLm, 4FingDv, 4ToeLm, and TotPore (0.84–0.74). Suplab in females, Suplab and Inflab in males have moderate loading; all other head scalation traits load weakly on PC1. Females have SnS strongly loading on PC2; other traits load "significantly" less. Inflab has the highest loading in male PC2.

The DFA sets for females and males share some of the same characters strongly influencing

TABLE 4. Summary of select scalation characters in Burmese-western Chinese *Hemidactylus bowringii* samples. Character abbreviations are defined in the Appendix A. Sample sizes are in parentheses. TotPore for adult males only.

| Sample | SnS | NaInf | Suplab | ChinSD | TotPore | 4FingLm | 4FingDv | 4ToeLm | 4ToeDv |
|---|---|---|---|---|---|---|---|---|---|
| Yunnan (16) | 3.4±0.62 | 0.8±0.40 | 9.5±0.63 | 0.2±0.45 | 29.6±1.67 | 7.7±0.45 | 5.2±0.43 | 9.5±0.82 | 5.9±0.50 |
| [also 26°] | 3–5 | 0–1 | 9–11 | 0–1 | 28–32 | 7–8 | 5–6 | 8–11 | 5–7 |
| Kachin (16) | 3.2±0.40 | 0.6±0.50 | 10.7±0.73 | 0.2±0.45 | 28.7±1.56 | 8.1±0.81 | 5.3±0.48 | 10.4±0.51 | 6.0±0.63 |
| | 3–4 | 0–1 | 9–11 | 0–1 | 26–28 | 7–9 | 4–6 | 9–11 | 5–6 |
| 25° (11) | 3.2±0.40 | 0.7±0.47 | 10.8±0.40 | 0.3±0.47 | 29.1±1.68 | 7.8±0.60 | 5.2±0.40 | 10.4±0.50 | 5.9±0.54 |
| | 3–4 | 0–1 | 9–11 | 0–1 | 27–31 | 7–9 | 5–6 | 10–11 | 5–7 |
| Sagaing (18) | 3.2±0.52 | 0.9±0.32 | 9.8±0.81 | 0.2±0.43 | 25.6±1.81 | 7.6±0.62 | 4.8±0.94 | 9.7±0.69 | 5.3±0.69 |
| | 3–5 | 0–1 | 8–11 | 0–1 | 23–28 | 7–9 | 3–6 | 8–11 | 4–6 |
| 22° (14) | 3.1±0.27 | 1.0±0.0 | 9.9±0.54 | 0.1±0.36 | 26.7±2.06 | 7.8±0.58 | 5.1±0.62 | 10.0±0.55 | 5.7±0.47 |
| | 3–4 | 1 | 9–11 | 0–1 | 23–28 | 7–9 | 4–6 | 9–11 | 5–6 |
| Shin-Ma-Taung | 2.9±0.38 | 0.14±0.38 | 8.1±0.69 | 0.0±0.0 | 21.0±2.83 | 6.6±0.54 | 3.6±0.53 | 8.3±0.95 | 4.1±0.90 |
| (7) | 2–3 | 0–1 | 7–9 | 0 | 19–23 | 6–7 | 3–4 | 7–9 | 3–6 |
| Mandalay (18) | 2.9±0.24 | 1.0±0.0 | 9.9±0.47 | 0.2±0.38 | 25.7±2.31 | 7.8±0.39 | 4.9±0.24 | 9.9±0.58 | 5.8±0.38 |
| | 2–3 | 1 | 9–11 | 0–1 | 21–28 | 7–8 | 4–5 | 8–11 | 5–6 |
| Shwe-Settaw (28) | 3.1±0.44 | 0.6±0.51 | 9.2±0.83 | 0.1±0.28 | 23.3±2.13 | 7.1±0.60 | 4.2±0.60 | 9.4±0.96 | 4.7±0.61 |
| [also 20°] | 2–4 | 0–1 | 8–11 | 0–1 | 18–26 | 6–9 | 3–6 | 7–11 | 4–6 |
| Yangon (4) | 3.0±0.0 | 0.0±0.0 | 9.7±0.96 | 0.0±0.0 | 25.0±0.0 | 8.0±0.0 | 4.2±0.50 | 10.0±0.0 | 5.2±0.0 |
| | 3 | 0 | 9–11 | 0 | 25 | 8 | 4–5 | 10 | 5–6 |

the discrimination function. NaInf is the highest for both males and females. For females, 4ToeDv, 4ToeLm, and 4FingDv comprise the next, not distant, set of important discrimination traits; for males, the next set is Chin, 4ToeLm, TotPore, and 4FingLm. The resulting Jackknife classification matrices display dissimilar results with strikingly different accuracy (average accuracy 52% females, 67% males). For females, only Mandalay (accuracy 80%) and China (67%) exceeds 60% (Fig. 3). In females, Sagaing and China misclassifications are assigned widely in other northern samples, although Mandalay receives the most individuals. The misclassifications for Shwe-Settaw are in Yangon; Yangon's in Shwe-Settaw and Shin-Ma-Taung, and Shin-Ma-Taung in Shwe-Settaw. In males, four samples (Kachin, Mandalay, Shwe-Settaw, Shin-Ma-Taung) have accuracy >75%. Shin-Ma-Taung's two males are correctly assigned, only two Shwe-Settaw males ($n$ = 14) are incorrectly assigned (Sagaing) and similar misclassification for Mandalay ($n$ = 7) with one individual to Kachin (Fig. 3). China's misclassifications are to Kachin and Mandalay; Sagaing's to China, Mandalay, and Shwe-Settaw; and the single Yangon male is classified with Shwe-Settaw males.

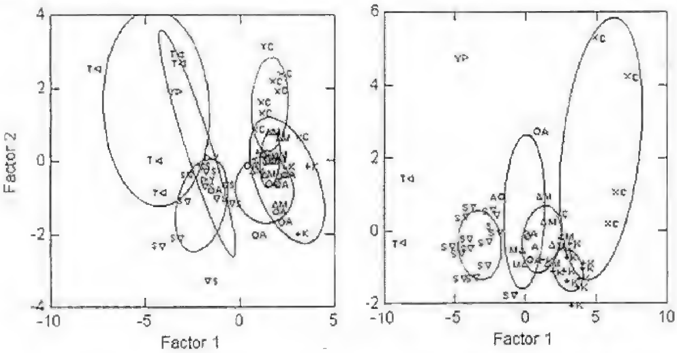


FIGURE 3. DFA canonical score plots for scalation data of adult females (left) and males (right) of the *Hemidactylus bowringii* locality samples. The ellipses define the 50% probability limits of each sample locality; capital letters denote locality and are identified in Table 1

DFA of the latitudinal samples was performed only on adult males, owing to the likely importance of TotPore in male discrimination. TotPore was the most important discriminator for males, although Chin and 4ToeLm had near equal *F*s; SnS was less but still weighed heavily. The average accuracy (30%) was low with only the 25° sample (57%) exceeding 50% accuracy, and in four of the nine latitudinal samples, no individuals were correctly classified.

Several scalation traits were not quantified during the initial character selection and definition. The aforementioned analyses suggested that some samples were consistently differentiated, and this result urged a re-examination of scalation features. That re-examination revealed several features related to the traits characterized. Our recorded data had three chin (postmentals) characters (Chin, ChinSAs, ChinSD). Two other chin scale morphologies are observed in our samples. The recorded chin characters are uniform or nearly so across all samples, hence show no evidence of regional differentiation. The medial contact of left and right 1st postmental scales (Chin) is variable, usually greatest when postmental scales are large; 2nd postmental scales do not contact medially in any of *H. bowringii* examined. Of the uncoded chin morphologies, the first concerns the relative size of the first postmentals and the nature of the posterior edge formed by the abutting 1st postmental scales. Large scales are elongate pentagons producing a convex to slightly angular posterior edge (Fig. 4) in association with the 2nd postmentals. The small condition has squarish scales posteriorly forming a straight edge, often the edge is continuous across rearward edge of the 1st and 2nd postmental scales (Fig. 4). The large scale-convex edge condition occurs in nearly all Kachin and Yunnan individuals and the majority of the Sagaing and Mandalay ones; all Shin-Ma-Taung individuals display the small-straight edge condition, and this condition occurs in a few individuals in the Sagaing and Shwe-Settaw samples. In the latter two samples, the 1st postmental is an elongate pentagon but seemingly intermediate in size between the Kachin large and the Shin-Ma-Taung small condition.

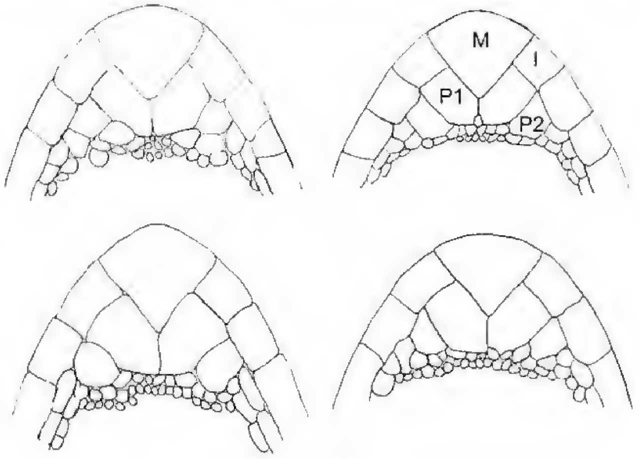


FIGURE 4. Schematic illustration of size and arrangement of chin scales in Burmese-China *Hemidactylus bowringii*. Clockwise from upper left: Kachin – CAS 233019; Shwe-Settaw – USNM 564821; Shin-Ma-Taung – CAS 215841; Hong Kong – MCZ R172987. Abbreviations: I, infralabial; M, mental; P, postmentals (1 primary or anterior, 2 secondary or posterior).

The second chin morphology relates to ChinSD and also involves size, i.e., the relative size of 2nd postmental scale to 1st. Because the 2nd is almost always smaller than the 1st, ChinSD data are uniform across our samples (Table 4); however, relative size segregates into two states, i.e., 2nd ≤ or ≥ half area of 1st postmental. The greater-than state is most frequent one in Yunnan, Sagaing, Mandalay, and Yangon samples, somewhat less than 50% in Kachin and Sagaing, and 100% in Shwe-Settaw and Shin-Ma-Taung. This relative size feature also is seen in the number of chin scales touching an infralabial and lying between the 2nd postmental scale and the 2nd–3rd infralabial suture: 1, occasionally 2, scales in specimens with the larger postmentals; and 2 or 3 postmentals in individuals with small 2nd postmental scales.

Suplab is regionally uninformative as we defined it. The supralabials of Shin-Ma-Taung seem larger than those of most individuals from elsewhere. The number of entire supralabials in front of the anterior edge of the exposed eyeball is 4 (mode) to 5 for Shin-Ma-Taung and, modally, 5 or 6, (range 5 to 7, except 4–7 for Shwe-Settaw) for the other samples.

Subdigital lamellae display regional differentiation among the samples. Shin-Ma-Taung [SMT] possesses the lowest lamellar counts (mean and range) of the seven locality samples (Table 4). The other six localities share similar means and ranges for the hand – 4FingLm and 4FingDv – although Shwe-Settaw [SS] and Yangon are intermediate between SMT and the other northern and eastern localities. A nearly identical pattern exists for the hindfoot lamellar characters (Table 4) with SMT lowest, SS and Yangon intermediate, and the other samples highest. The only difference is the mean and range of 4ToeDv of Sagaing sharing the intermediate position with SS and Yangon. Reduced lamellae on the first toe also show a similar distributional pattern with SMT lowest (3–5), SS and Yangon intermediate (4–5), and the other samples highest (5 or 5–6).

TABLE 5. Comparison of select mensural and scalation characters among adult males of the three samples of the Burmese and South Chinese *Hemidactylus bowringii* complex. Abbreviations as in Table 3 and 4.

| | North | South | Hong Kong |
|---|---|---|---|
| n | 30 | 17 | 8 |
| SVL | 48.0±3.69<br>39.8–53.2 | 38.2±2.92<br>34.4–43.9 | 44.4±2.67<br>39.9–46.9 |
| TrunkL | 22.1±2.36<br>16.9–26.2 | 17.0±1.64<br>13.9–20.5 | 19.8±2.31<br>15.4–22.2 |
| SnForel | 18.3±1.86<br>13.7–22.6 | 14.5±1.39<br>12.5–17.4 | 16.4±1.37<br>15.0–18.6 |
| HeadL | 12.1±0.85<br>10.2–13.4 | 9.7±0.95<br>8.3–11.1 | 11.3±0.83<br>10.2–12.7 |
| JawW | 7.3±0.59<br>5.8–8.4 | 6.3±1.20<br>5.6–10.3 | 7.5±0.38<br>6.9–7.9 |
| SnEye | 5.1±0.44<br>3.9–6.1 | 3.9±0.38<br>3.4–4.7 | 4.7±0.43<br>4.2–5.4 |
| ForeaL | 5.8±0.54<br>4.4–6.7 | 4.6±0.26<br>4.1–5.1 | 5.2±0.5<br>4.1–5.9 |
| CrusL | 6.6±0.66<br>5.0–8.0 | 5.2±0.44<br>4.6–6.4 | 5.5±0.42<br>4.8–6.0 |
| SnS | 3.1±0.51<br>2–5 | 3.0±0.35<br>2–4 | 2.6±0.52<br>2–3 |
| NaInf | 0.8±0.41<br>0–1 | 0.6±0.51<br>0–1 | 0.7±0.46<br>0–1 |
| Sublab | 10.0±0.72<br>9–11 | 9.4±0.86<br>8–11 | 9.4±0.52<br>9–10 |
| Chin | 1.9±0.43<br>0–2 | 1.9±0.48<br>0–2 | 1.2±0.46<br>1–2 |
| TotPore | 27.5±2.42<br>21–32 | 23.1±2.23<br>18–26 | 28.2±1.91<br>24–30 |
| 4FingLm | 7.9±0.72<br>7–10 | 6.9±0.56<br>6–8 | 8.2±0.46<br>8–9 |
| 4FingDv | 5.1±0.72<br>3–6 | 3.9±0.43<br>3–5 | 5.6±0.74<br>4–6 |
| 4ToeLm | 9.9±0.84<br>8–11 | 9.2±1.03<br>7–11 | 10.2±0.46<br>10–11 |
| 4ToeDv | 5.7±0.65<br>4–7 | 4.6±0.61<br>4–6 | 6.6±0.74<br>5–7 |

The preceding results add morphological support to the presence of two "*bowringii*" species in Myanmar and encourage the formal recognition of both; however, that path requires the resolution of what is true *H. bowringii*. Zug et al. (2007) suggested, on distributional data only, that the South China-Hong Kong populations were invasives. Because Hong Kong is the type-locality (restricted by M. Smith, 1935) of *H. bowringii*, a comparison of the morphology of representatives from this area with those from Burma is essential.

Lazell (2002) observed that Hong Kong area (Shek Kwu Chau; SKC) male *H. bowringii* ranged between 26.5 and 52.5 mm SVL, with the smallest mature male at 36 mm SVL. He did not provide a size range for adult SKC females, although he noted that six gravid females were 49–54 (mean, 50) mm SVL and that gravid females from other Hong Kong localities ranged 42–49 (mean 46) mm SVL. Our examination of a small sample (*n* = 10) from Hong Kong yields an adult SVL range of 40 to 47 mm (mean, 44 mm), generally equivalent to Lazell's data. Other morphometric aspects are summarized in Table 5 and compared to the Burmese samples [hereafter combined into a North (Yunnan, Kachin, Sagaing and Mandalay samples) and a South (Shin-Ma-Taung, Shwe-Settaw and Yangon samples) sample. Hong Kong [HK] males are generally intermediate in size between the males of the two Burmese populations, although somewhat closer to the North population. The heads of the HK males appear somewhat broader than the heads of either of the two

Burmese populations. This broadness is suggested by the HeadW to HeadL proportion (Table 6). Pairwise Student's *t* test comparisons among the three samples demonstrate significant differences between one or more pairs for each proportion; however, the ranges of all three samples overlap in all proportions even though the means appear distinct. The situation is likely identical for females but our HK sample contained only two adult females. The means for the HK females are nearly identical to Burmese females.

TABLE 6. Comparison of mean body proportions (%) among adults of three samples of the Burmese and South Chinese *Hemidactylus bowringii* complex. Character abbreviations for the proportions are identified in the Appendix A. Symbols: *n*, sample size; Student's *t* test probabilities <0.05 in pairwise comparison - * North to South samples, ° North to Hong Kong, ^ South to Hong Kong.

| | North | South | Hong Kong |
|---|---|---|---|
| *n* | 63 | 36 | 10 |
| Trunk/SV | 0.472* | 0.447* | 0.445° |
| SnFor/SV | 0.371* | 0.38* | 0.374 |
| Forea/SV | 0.121° | 0.118 | 0.116° |
| CrusL/SV | 0.137° | 0.134^ | 0.125°^ |
| HeadL/SV | 0.248° | 0.249 | 0.253° |
| HeadW/HL | 0.402° | 0.407^ | 0.435°^ |
| SnEy/HL | 0.418* | 0.396*^ | 0.417^ |
| NarEy/HL | 0.297* | 0.281*^ | 0.331°^ |
| EyEar/HL | 0.315* | 0.33* | 0.337° |

Comparison of scalation among the three samples also demonstrates overlapping ranges in all recorded traits of scalation. Some characters (SnS, Chin, TotPore, and all lamellae characters) show contrasting differences in means (Table 5). The degree of differences among the three samples tends to be greater between the South and HK samples. The uncoded chin scale pattern for HK is typically large pentagonal 1st postmentals forming a straight posterior edge. The 2nd postmentals are almost always small, ≤ 0.5 1st postmentals and occasionally very small and circular.

The syntypes of *Doryura Bowringii* Gray, 1845 are two juveniles (BMNH 1[1]34a – 20.4 mm and 32.2 mm SVL). They are faded to a uniform light beige and are flaccid, although the skin remains firm (Fig. 5). Body proportions lie within the ranges of those of the recent HK sample. The scalation traits that could be seen clearly (head scalation) also matched the HK sample. Digit lamellae characteristics could not be determined with certainty.

**Coloration**— Our initial examination to identified characters found no color or pattern features that could be seen on most specimens or precisely characterized for accurate data-capture in subsequent examination of specimens. Like most, perhaps all, *Hemidactylus*, *H. bowringii* lighten and darken their coloration in life. Half or more of the specimens examined were preserved in the light phase and appear nearly uniform grayish beige. In this phase, some individuals faintly display the longitudinal row of light spots on the side and the postocular stripe on cheek and anterior neck. Even in the dark phase, the pattern of dark dorsal marks is variably displayed.

In life, *H. bowringii* can be boldly patterned (Fig. 6). The general pattern for the dark phase is a tan to dusky tan background dorsally and laterally on head, neck, and trunk. Dark brown marks and cream spots create the *bowringii* pattern. Often a narrow dark V lies on the nuchal and diffuse dark markings occur on the neck and trunk. Dorsolaterally, and laterally, the dark marks form fragmented longitudinal stripes with the lateral one most sharply defined; this latter stripe extends from the nares to eye and from rear of eye to shoulder, thereafter broken by circular cream spots, and as a solid stripe onto the base of the tail. The dorsolateral stripe is always fragmented; it begins on the anterior neck and extends onto the base of the tail. Venter is immaculate from chin to the base of thetail, typically a light tannish white. The phase shift from dark to light causes a gradual loss of the intensity of the dark markings, with the light spots sometimes evident with the disappearance of the dark ones. Also the dark lateral stripe from eye to shoulder disappears more slowly, as also do the dorsal markings on the tail.

Differences between northern and southern populations are subtle. In northern individuals, the dark markings forming the dorsolateral stripe are anteroposterior elongate and yield a more discrete dorsolateral stripe; in southern individuals, these marks are transversely elongated, yielding a barred or ladder pattern on the dorsum of the trunk (compare the Shwe-Settaw and Pyin-Oo-Lwin individuals in Fig. 6). The transverse nature is more evident dorsally on the tail, with dark chevrons in southern individuals vs. dark spots in northern ones.

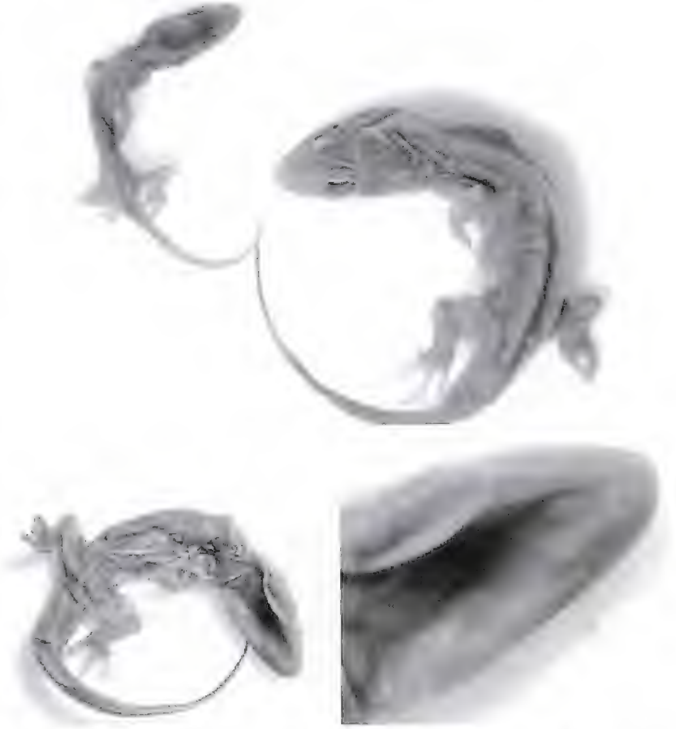
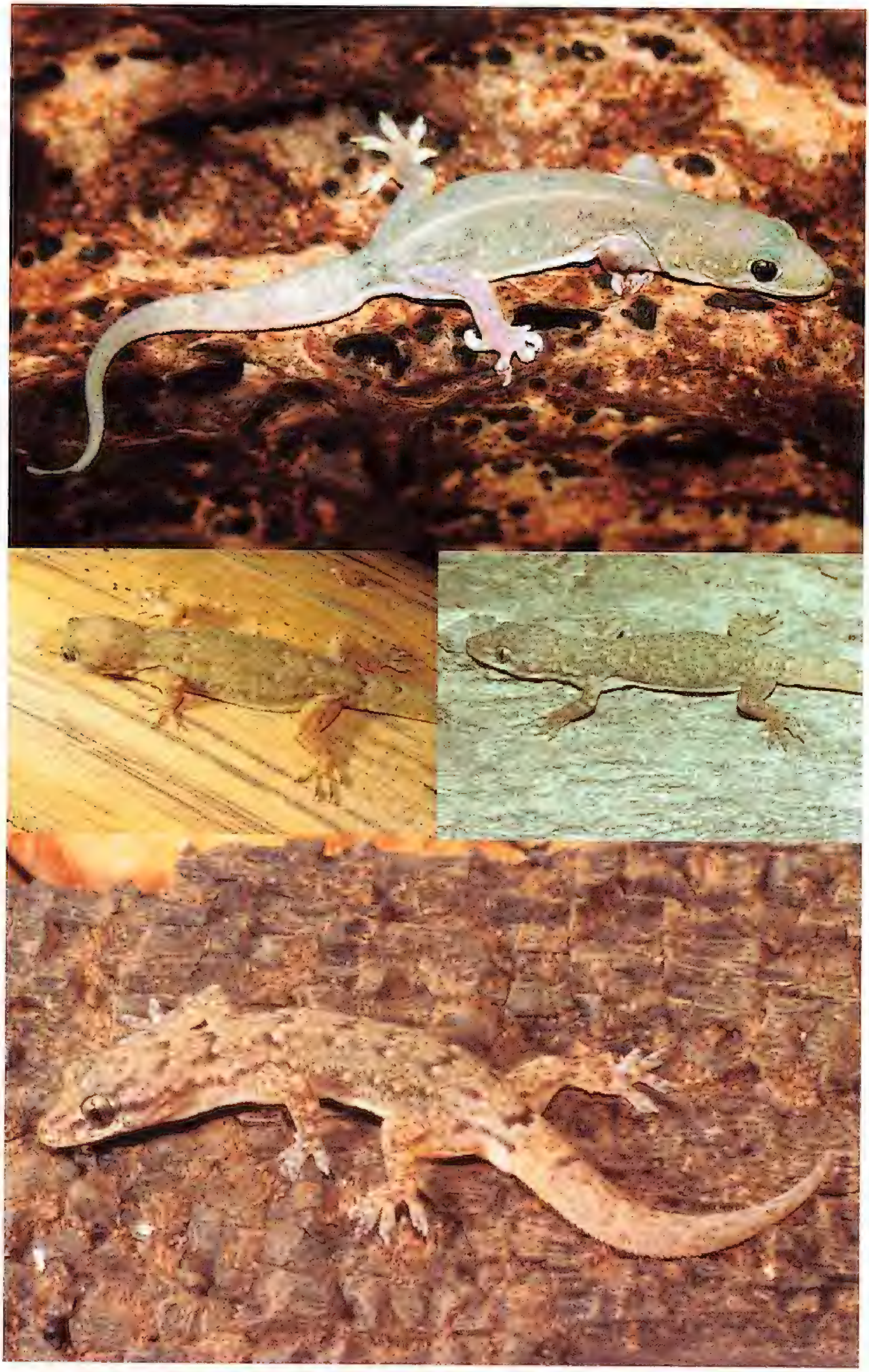


FIGURE 5. Syntypes of *Hemidactylus bowringii* . Top: right large juvenile (BMNH 2007.1, lectotype; 32.2 mm SVL); left, small juvenile (BMNH 2007.2 paralectotype; 20.4 mm SVL). Bottom: ventral view and chin of lectotype (BMNH 2007.1).

The general pattern description applies to the *H. bowringii* adults from Hong Kong. The HK pattern is more similar to that described above for northern Burmese individuals, although many HKs have dark chevrons or transverse bars on the tail dorsum. Also many HK individuals have a broad cream stripe on the neck above the lateral stripe (see Karsen 1986:84), and in a few individuals, the light area extends forward to the eye.

## MORPHOLOGICAL DIFFERENTIATION—DISCUSSION

SEXUAL DIMORPHISM.— The few samples and traits showing dimorphism in adults argue that Burmese-Yunnan populations lack sexual dimorphism, with the exception of the presence of femoral-precloacal pores (TotPore) in males, although the small sample sizes and the uneven representation of females and males in most samples do not lend robustness to this interpretation. These two factors would seem more likely to offer false positive identification of dimorphism than the opposite. Further the lack of concordance between the two samples with mensural-dimorphic traits (21° - HeadH, SnForelL; Mandalay – EyeEar, CrusL) and similarly between the two samples with scalation-dimorphic characters (Yunnan – Inflab; Sagaing – 4FingLm, 4FingDv, 4ToeLm, 4ToeDv) supports the likelihood these putative dimorphic traits are simply a stochastic result of measurement or sampling. This interpretation is supported by the overlap of individual specimens in the 21° and Mandalay samples; 12 Mandalay specimens (6 of each sex) are part of the 21° sample, yet the two samples do not share the same set of dimorphic characters. There are few comparable examinations of dimorphism in other populations of tropical Asian *Hemidactylus*. Brown and Alcala (1978) reported no sexual dimorphism in the Philippine *H. brookii, H. frenatus*, or *H. platyurus*. The size range of adult females and males in these three species overlapped broadly. Zug



(1991) observed only that females had narrower heads in Fijian *H. frenatus*. Lazell (2002) examined the reproductive biology of *Hemidactylus* from Shek Kwu Chau, an islet in the Hong Kong region. He found no sexual dimorphism other than presence-absence of precloacal-femoral pores. He specifically notes the absence of size dimorphism (adult females 42–49 mm, males 36–52 mm SVL). Our HK sample is too small to adequately test for dimorphism.

Males and females differ in the presence of the femoral-precloacal pore series. In our total sample, we observed no females with secreting pores and no adult males lacking pores. This dichotomy is a common attribute of many geckos.

**Mensural traits.**— Both univariate and multivariate analyses reveal a trend in body size. This trend is displayed in all mensural characters, except JawW, because they are strongly correlated, i.e., $r \geq 0.75$ and usually $> 0.80$ because of the intercorrelation of the mensural traits. These correlations would have been stronger (higher $r$ values) if our samples included the full range of life-stages. Our samples emphasized large juveniles and adults, both from a collecting bias and our data-gathering emphasis.

This emphasis on samples of large juveniles and adults has the advantage of reducing variation within each of the locality and latitudinal samples, hence permitting a more robust comparison among the samples. The samples, even the smaller ones, display low to normal variance as judged by low to moderate $V$s (6 to 10%) for all characters, except SnW (commonly ~20%). As noted in the results section, we excluded SnW from our analyses owing to CM and GZ measuring this trait differently.

We noted in the results section the occurrence of larger geckos in the northern and Mandalay samples (Table 3). Although the measurement ranges of the northern and southern samples (Shin-Ma-Taung, Shwe-Settaw, Yangon) overlap, the means are significantly different, and only the Sagaing sample's mean approaches the maximum size (SVL) of the southern samples. This observation led to our combination of the individual Burmese-Yunnan samples into two regional samples for examination with the topotypic Hong Kong sample. These three samples (Table 5) proved significantly different from one another (SVL: N-S $t = 13.41$ $df = 97$ $p<0.001$, N-H $t = -2.64$ $df=71$ $p=0.01$, S-H $t = 6.62$ $df = 44$ $p<0.001$). We also observed that body proportion ranges overlapped among these three regional samples, yet the sample means show significant differences (Table 6).

**Meristic traits.**— No aspect of scalation uniquely distinguishes a sample or set of samples. A few traits show a low-frequency of occurrence of one condition in a limited geographic area, such as the absence of a median 'supranasal' scale in southern samples. Others, e.g., Suplab, show a weak north-south cline. Only TotPore has a distinct clinal pattern with the northern-most and southern-most samples significantly different from one another, although their ranges overlap (Table 4). Subdigital lamellae are fewer and with more divided ones in the Shin-Ma-Taung sample. The other sample-localities broadly overlap, although the condition in Shwe-Settaw and Yangon is somewhat intermediate. Shin-Ma-Taung geckos also seem to differ from other Burmese *H. bowringii* by somewhat larger supralabial scales. Scale shape and size on the chin show two 1st postmental patterns. Yunnan and Kachin individuals have somewhat larger 1st postmentals and these scales form an angular (convex) posterior edge between the 2nd postmentals. All Shin-Ma-Taung and many Shwe-Settaw geckos have proportionately smaller 1st postmentals than in the northern samples; this condition and also often smaller 2nd postmental produce a straight posterior

Figure 6 (left). Color patterns of *H. bowringii* group geckos from Myanmar and China. Top:*H. bowringii* – China: Guangdong; Nan Ao Island, Tai Zhu Ao [photographer Hou Mian; © The Conservancy Agency]. Middle left/right: *H. aquilonius* – Myanmar: Mandalay Divis.; Pyin-Oo-Lwin [G. Zug; MBM-USfs 36837]. *H. aquilonius* – Myanmar: Sagaing Divis.; Chatthin Wildlife Sanctuary [G. Zug; USNM 520556]. Bottom: *H. thayene* – Myanmar: Magway Divis.; Shwe-Settaw Wildlife Sanctuary [G. Zug; USNM 564821-holotype].

edge of the postmentals. Sagaing and Mandalay samples show a mix of these two posterior-edge patterns.

**COLORATION.**— Both the faintness and uniformity of coloration in the light phase and the irregular-edging of the dark marks in the dark phase cloud coloration differences among the samples. At first glance, the reaction is to declare that all "*bowringii*" look the same; however, some subtle differences exist, although these differences require confirmation by image-documentation in samples of living geckos. We suggest that the north and south Burmese samples segregate on the nature of the dorsolateral dark stripe with the former possessing a better defined, more contiguous dorsolateral stripe vs. a slight transversely barred pattern in the latter. Hong Kong "*bowringii*" have a broad cream stripe or patch on each side of the neck, absent in the Burmese individuals.

Lazell (2002:21) observed that Boulenger's illustration (1885: pl. XII) was peculiar in the random scattering of irregular-sized light spots on the dorsum. We agree, perhaps Boulenger's illustrator depicted patches of loose [pre-shed] scales.

**GEOGRAPHIC DIFFERENTIATION: CONCLUSIONS.**— As mentioned above, no character has a unique state for the differentiation of the two Burmese genetic lineages of *Hemidactylus bowringii* identified by Carranza and Arnold (2006). Morphological differences, however subtle, exist and display geographic discontinuity between northern and southern samples. The most evident aspect is adult size, both mean and minimum size at maturity. Northern samples (Kachin, Yunnan, Sagaing, Mandalay) have larger adults (Table 3; means 44–49 mm SVL, minimum 40–45 mm) as compared to the smaller adults (Table 3; means 37–42 mm SVL, minimum 34–38 mm) of the southern samples (Shin-Ma-Taung, Shwe-Settaw, Yangon). [Note: The Shan specimen analyzed genetically by Carranza and Arnold derived from Shwe-U-Daung Wildlife Sanctuary which overlaps the border of Shan State and Mandalay Division. Because we had specimens from both sides of the sanctuary, we included the Shan specimen in the Mandalay locality-sample.] A few aspects of scalation also show populational differences. In males, the number of precloacal pores (TotPore) overlaps only slightly between northern and southern samples, with significant differences of the means (north – 26–30, south – 21–25). Digital lamellae also display north-south differentiation. Even though the means and ranges of 4FingLm and 4ToeLm strongly overlap, the number (means) of divided lamellae for both fore- and hindfeet (4FingDv, 4ToeDv; Table 4) do not.

In multivariate space (Figs. 2, 3), the locality samples regularly divide into sets of north and south clusters, although as in single character comparisons, overlap occurs among the northern and southern samples. The China and Kachin samples overlap strongly in all analyses, and Mandalay commonly shares this overlap. Sagaing often overlaps with both the northern and southern (Shwe-Settaw, Yangon) samples. Shin-Ma-Taung is the most distinct locality, with it specimens always well outside the 50% confidence ellipse of northern samples and slight overlap with the other two southern ones. This position suggests that the Shin-Ma-Taung population might be genetically distinct from the northern and other southern populations; however, we do not accept that interpretation presently. We, however, interpret the morphological differences reported above as concordant with the mtDNA sequence data of Carranza and Arnold (2006) and advocate the recognition of two species within Myanmar.

This interpretation is re-enforced by results from the comparison of Hong Kong *H. bowringii* with the Burmese samples. The Hong Kong sample is intermediate between the two Burmese combined samples (Table 5, Fig. 7). The three samples are well segregated in multivariate space with only a northern individual or two overlapping into the Hong Kong 50% confidence ellipse. This segregation indicates that the South China populations represent another species of the *H. bowringii* group.

## TAXONOMIC NOTES AND DECISIONS

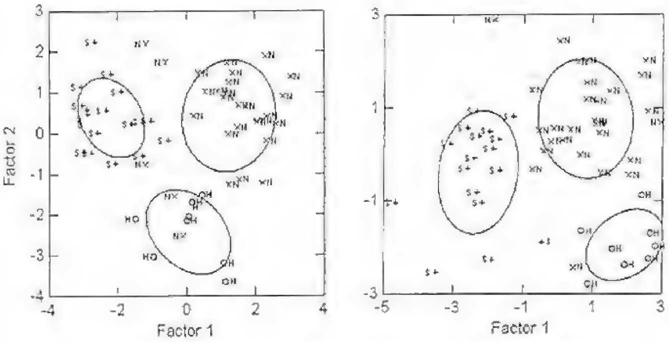


FIGURE 7. DFA canonical scores plots for mensural (left) and scalation (right) data of adult males of three *Hemidactylus bowringii* group samples. The ellipses define the 50% probability limits of each sample; capital letters denote locality (H, Hong Kong; N, northern Myanmar sample; S, southern Myanmar sample).

Our interpretation that *Hemidactylus bowringii* geckos in Myanmar represent two species is restricted to populations from Yangon northward. Our examination of *H. bowringii* populations outside of central and northern Myanmar has been perfunctory, although sufficient to suggest that at least two of these populations deserve taxonomic recognition. Before preceding with this nomenclatural step, three taxonomic matters require resolution: 1) definition of the *H. bowringii* species group; 2) proof that Smith's (1935) restriction of the type-locality of *bowringii* to "Hong-Kong" is appropriate; that is, the type specimens match the morphology of the present Hong Kong *bowringii*; 3) demonstration that "*bowringii*" from Tanintharyi [Myeik Beik] are the same as one of central and northern populations or different from them in order that the name *Leiurus berdmorei* Blyth can be correctly applied.

The *bowringii* species group consists of the populations of *Hemidactylus* geckos previously labeled *H. bowringii*, which occurs from the terai of Nepal, northern India (Sikkim, West Bengal), adjacent Bangladesh, Myanmar, adjacent northwestern China (Yunnan), and southern China (Hainan eastward) to Taiwan and Ryukyu Islands (Zug et al. 2007). These geckos have a dorsal and lateral trunk surface of uniformly small granular scales; the tail oblong in cross-section, indistinctly segmented with a small spine-like scale ventrolaterally on each side at posterior edge of each segment; and 7 to 11 lamellae on the underside of the 4th toe, about half of these lamellae divided medially.

In spite of an earlier proposal (Zug et al. 2007) that the southern China populations were introduced, our current interpretation is that these populations are natural and further that they represent a different species from those of Myanmar. This interpretation is important because the Hong Kong population is topotypic. Although Gray (1845) did not provide a type-locality, Smith (1935) restricted the type-locality to Hong Kong. Smith did not explain his restriction; however, Lazell (2002) notes that the donor (C. Bowring [actually J.C. Bowring]) of the syntypes was in Macao and possibly Hong Kong by 1842, thus increasing the likelihood that the types did derive from that area of southern China. Our examination of the poorly preserved syntypes shows a tentative match with recently collected Hong Kong specimens. The deteriorating condition of the syntypes does not permit an unequivocal assignment. We designate the largest syntype as the lectotype.

The condition of the Zoological Survey of India holotype of *Hemidactylus berdmorei* is even worse than that of the *bowringii* syntypes. Blyth (1853) described a gecko *Leiurus Berdmorei* (subsequently synonymized with *H. bowringii*) from Mergui (=Myeik) of the Tenasserim coast. His description noted that the specimen matches Gray's African *Leiurus* with the exception of no webbing at base of the toes. Blyth's description, otherwise, concerns color and pattern. The description is generalized, mentioning "4 longitudinal blackish streaks along the back and sides, 3 or 4 interrupted cross-bands of the some on the upper surface of the tail, . . ." These two traits and the others mentioned by Blyth have a general match with the central and northern Burmese *H. bowringii* group members. The coloration also matches that of *Hemidactylus garnotii*, which is more boldly striped than *bowringii* group members in the dark phase. The holotype was supposed lost but recently relocated by Das and Dattagupta (1998). Disastrously the specimen has disintegrated and is in fragments. We estimate the SVL of the holotype ZSI 6173 as approx. 56 mm [By assuming the museum tag in Das and Dattagupta (1998) fig. 1 is 19 mm long and SnForel 22 mm; SnForel/SVL averages 38% (Zug et al. 2007); these values yield the SVL estimate.]. At this time, we have no recent *H. bowringii* group specimens from southern Tanintharyi to verify this estimate; however, if our SVL estimate is correct, the Mergui geckos (type locality) are at the upper end of the SVL range of the northern Burmese and southern Chinese populations, and match the average SVL of Burmese *H. garnotii*.

Our study did not encompass samples from west of Myanmar, thus we cannot address the specific status of these populations. These populations are unlikely to be "true" *H. bowringii*. Possibly, they consist of one or both of the new Burmese species; however, for the present, we recommend that their uncertain status be identified by including the *bowringii* epithet in quotes.

## *Hemidactylus bowringii* Species Group Members

### *Hemidactylus bowringii* (Gray, 1845)

Figures 4–6.

**Lectotype.**— BMNH 2007.1 (formerly 1[1]34 a), an unsexed juvenile without specific locality, presented by C. Bowring in 1842. Smith (1935) restricted the type-locality to Hong Kong, see preceding Taxonomic Notes section for explanation.

**Paralectotypes.**— BMNH 2007.2 (formerly 1[1]34 a), an unsexed juvenile without specific locality, presented by C. Bowring in 1842.

**Diagnosis.**— *Hemidactylus bowringii* is a member of the *H. bowringii* species group and differs from other members of this group by the possession of the following set of traits: adult SVL averaging 44.4 mm (range, 40–47 mm); 8–9 fourth finger lamellae (mean, 8.2); 4–6 of fourth finger lamellae divided (5.6); 10–11 fourth toe lamellae (mean, 10.2); 5–7 of fourth toe lamellae divided (6.6); 24–30 precloacal pores in males (28.2); posterior edge of first postmental scales straight or smoothly convex; solid dark lateral stripe from snout to anterior trunk, series of dark dashes forming dorsolateral stripe on trunk, and dorsal surface of tail with dark chevrons bordered posteriorly by white bars.

**Etymology.**— J.E. Gray named this species to acknowledge the donation of the syntypes and other specimens by John Charles Bowring, 1821–1893. See Lazell (2002) for a brief biography of J.C. Bowring.

**Description of the lectotype.**— The lectotype is the larger of the two syntypes. Both are poorly preserved and presently soft and flaccid, and faded to a uniform whitish tan.

An unsexed juvenile of 32.2 mm SVL, 15.9 mm TrunkL, 13.6 mm SnForel, 3.8 mm ForeaL, 3.8 mm CrusL, and 29 mm TailL (broken). Head pentagonal in outline, snout bluntly pointed, and covered dorsally with small granular scales in juxtaposition: 9.0 mm HeadL, 6.8 mm JawW, 4.0 mm HeadH, 3.6 mm SnEye, 2.7 mm NarEye, 2.7 mm EyeEar, 1.0 mm SnW. Bilateral measurements from right side.

Plate-like head scales confined to margin of mouth; rostral trapezoidal, top edge slightly concave and clefted, bordered behind by 3 internasal scales; naris surrounded by internasal, 2 nasal and rostral scales; 9 (right) Suplab; 7 Inflab; broad triangular mental scale bordered posteriorly by large 1° postmentals; latter abutting posteriorly on lateral half by 2° postmental on each side; posterior border of 1° postmental transversally straight; 2° postmental less than half area of 1° postmental.

Body slightly depressed, moderately robust, covered by small, smooth granular scales dorsally and laterally; scale size increasing gradually from middorsally to ventrolaterally and more abruptly to ventral scales; ventral scales several times larger than dorsal scales, smooth plate-like and slightly overlapping; indistinct ventrolateral fold on each side of trunk. Tail ellipsoidal in cross-section, indistinctly segmented; small granular scales dorsally, gradually enlarging laterally to become cycloid ventrolaterally onto ventral surface, and ventromedially large rectangular and slightly overlapping; ventrolateral fringe indistinct. Limbs well-developed; all digits well-developed, each bearing a claw and digital pad with rectangular lamellae, 7 4FingLm, 5 4FingDv, 10 4ToeLm, 6 ToeDv. 24 femoral and precloacal pores, continuous series on each side (13/11, left/rt), separated medially by 2 nonpore scales.

Coloration from Gray (1845:156): "Grey-brown, with minute specks; tail with narrow pale cross bands, darker-edged in front; limbs and tail white-speckled; . . "

VARIATION OF HONG KONG POPULATION.— Adults range 36–52 mm SVL (Table 5; Lazell 2002) averaging ~44 mm. Other body measurements are highly correlated with SVL, and there is no apparent sexual dimorphism in mensural characters. Aside from the presence (males) and absence (females) of precloacal-femoral pores, scalation also appears non-dimorphic. Variance is low ($v \leq 8$; Suplab, TotPore, 4FingLm, 4ToeLm) to modest ($v \leq 14$; Inflab, 4FingDv, 4ToeDv). Scalation ranges are: 2–3 SnS, 0–1 NaInf, 9–10 Suplab, 6–8 Inflab, 24–30 TotPore, 8–9 4FingLm, 4–6 4FingDv, 10–11 4ToeLm, and 5–7 4ToeDv. We note that Ota's brief description (1989) of Taiwanese *H. bowringii* has 23–31 TotPore and tail without lateral denticulations. These minimal data offer tentative confirmation of *H. bowringii* occurring across southern China to Taiwan and Ryukyu islands.

DISTRIBUTION AND NATURAL HISTORY.— Because our study examined only specimens from the Hong Kong area, we cannot unequivocally claim that *H. bowringii* is the species occurring from eastern Indochina through southern China to Taiwan and the Ryukyus; nevertheless, we recommend that intrepretation.

According to Lazell (2002; Hong Kong area), *H. bowringii* is one of the three most abundant reptiles and occurs widely from human dwellings to woodlands. Lazell's reproductive data show egg deposition begins in late March and extends to late August. Hatchlings first appear in late June and then through late September; incubation is approximately 30–45 days. Size-class growth data suggest that *H. bowringii* attain maturity in 9 to 11 mo from hatching.

### *Hemidactylus berdmorei* (Blyth, 1853)

HOLOTYPE.— ZSI 6173. A fragmented specimen (Das and Dattagupta 1998) of questionable sex, derived from "Mergui, where procured by Capt. Berdmore." (Blyth 1853).

DIAGNOSIS.— The fragmentary nature of the type and the absence of a recent series of southern Tanintharyi specimens prevent a characterization of this species. Extrapolation from the dimensions of the head to shoulder fragment of the holotype indicate an approximate SVL of 56 mm.

ETYMOLOGY.— E. Blyth named this species and others for Capt. Thomas Matthew Berdmore, 1811–1859, in appreciation for Berdmore's donation of Burmese specimens. Although a soldier, Capt. Berdmore was in charge of the Forest Office, Calcutta, and in 1849, he accompanied Dr. Falconer of the Calcutta Botanical Garden on a trip to inventory forests in Tenasserim (biographic details *in litt.* C. Wemmer, 1 June 2007).

DESCRIPTION OF THE HOLOTYPE.— Fragmentary.

DISTRIBUTION.— The type derives from the southeastern tip of Myanmar, i.e., southern Tanintharyi State.

**Comment.**— This name is tentatively retained within the *Hemidactylus bowringii* species group. The disintegrating condition of the holotype and the absence of recently collected specimens from the vicinity of the type-locality of *Leiurus Berdmorei* Blyth, 1853 prevent a comparison of these geckos with the central and northern *H. bowringii* group members.

### *Hemidactylus aquilonius* McMahan and Zug, sp. nov.

Figures 4, 6, 8.

**Holotype.**— CAS 233019, adult male from Myanmar, **Kachin State**, He Pu village (25°06′14″N 96°21′55″E, Mohnyin Township) collected by a He Pu villager, 17 May 2003.

**Paratypes.**— Myanmar, **Kachin State**, Putao – CAS 221204–205, 221208, USNM 564840; Myanmar, **Kachin State**, Machanbaw 230218; Myanmar, **Kachin State**, Pidaung Wildlife Sanctuary – CAS 230368, 230371–374; Myanmar, **Kachin State**, He Pu village – CAS 232810–811, 232882, 232884, 233000, 233019.

**Diagnosis.**— *Hemidactylus aquilonius* is a member of the *H. bowringii* species group and differs from other members of this group by the possession of the following set of traits: adult SVL averaging 48.0 mm (range, 40–53 mm); 7–10 fourth finger lamellae (mean, 7.9); 3–6 of fourth finger lamellae divided (5.1); 8–11 fourth toe lamellae (9.9); 4–7 of fourth toe lamellae divided (5.7); 21–32 precloacal pores in males (27.8); posterior edge of first postmental scales usually angular to smoothly convex; dark dorsolateral trunk stripe composed of elongate dash-like spots; and dorsal surface of tail with small, irregular dark spots rarely bordered by white.

**Etymology.**— The specific name is derived from the Latin *aquilonius* for northern or northerly and refers to the northern distribution of this species in Myanmar and adjacent China. The name is proposed as an adjective.

**Description of the holotype.**— An adult male of 51.3 mm SVL, 25.8 mm TrunkL, 19.1 mm SnForel, 6.2 mm ForeaL, 7.0 mm CrusL, and 44 mm TailL (reg). Head pentagonal in outline, snout bluntly pointed, and covered dorsally with small granular scales in juxtaposition: 12.9 mm HeadL, 7.8 mm JawW, 5.5 mm HeadH, 5.3 mm SnEye, 3.5 mm NarEye, 4.2 mm EyeEar, 1.0 mm SnW. Bilateral measurements from right side.

Plate-like head scales confined to margin of mouth; rostral trapezoidal, top edge slightly concave and depressed, bordered behind usually by 3 internasal scales; 36 interorbital scales; naris surrounded by 2 nasal scales, rostral, and extension of 1st supralabial; 10/9 (left/right) Suplab, 5/4 Suplab in front of anterior edge of eye; 8/8 Inflab; broad triangular mental scale bordered posteriorly by large 1° postmentals; latter bordered on lateral half by 2° postmental on each side; posterior border of 1° and 2° postmental angularly concave. 2° postmental about half area of 1° postmental, left and right postmentals equal sized.

Body slightly depressed, moderately robust, covered by small, smooth granular scales dorsally and laterally; scale size increasing gradually from middorsally to ventrolaterally and more abruptly to ventral scales; ventral scales ≥ 4X larger than dorsal scales, smooth cycloid and slightly overlapping; approximately 90 scales around midbody; ventrolateral fold on trunk indistinct. Tail ellipsoidal in cross-section, indistinctly segmented; small granular scales dorsally, gradually enlarging laterally to become cycloid ventrolaterally onto ventral surface, and ventromedially large rectangular and slightly overlapping; ventrolateral fringe not evident. Limbs well-developed; all digits well-developed, each bearing a claw and digital pad with rectangular lamellae, 8/7 4FingLm, 6/4 4FingDv, 10/9 4ToeLm, 6/6 4ToeDv. Femoral and precloacal pores (16/15) continuous on each side, separated medially by 2 nonpore scales.

Coloration in preservative tannish ground color with brown markings. Dorsally head lightly speckled with tiny brown spots, small irregular brown spots dorsally on neck, trunk and tail; brown spots dorsolaterally and laterally forming vague longitudinal stripes, midlaterally brown stripe from front of eye to axilla through eye and above ear, highly interrupted on trunk and fading on base of tail; longitudinal white spots dorsolaterally from base of neck onto tail. Venter from chin onto tail unicolor light tan.

INTRASPECIFIC VARIATION.— The regional variation of *H. aquilonius* is described in the preceding Results and Discussion sections as the samples from Yunnan, Kachin, Sagaing, and Mandalay (or northern samples). Briefly, adult size ranges from 40 to 56 mm SVL (Table 5); other body measurements are strongly correlated to overall body size. Body size averages larger in the two northern-most samples (both 49 mm SVL), Mandalay is intermediate, and Sagaing the lowest (44 mm) (Table 3). The smallest adult *H. aquilonius* occurs at Chatthin. Scalation is generally similar (Table 4) in the four northern samples, and there is no evidence of a north-south or east-west cline with the exception of TotPore. The Yunnan sample averages 29.6 (TotPore), the hightest number of femoral-precloacal pores; Kachin is nearly the same; and Mandalay-Sagaing have a lower TotPore mean, nearly identical to one another (25.6, 25.7, respectively).

A large adult male (56.6 mm SVL) from Pyin-Oo-Lwin was excluded from the Mandalay sample owing to its size and atypical coloration, i.e., unicolor brown dorsally and laterally with the exception a dark brown (although faded) stripe on the trunk. The stripe is punctuated by a series of light tan spots. Its scalation matches other *H. aquilonius* and is now identified as that species.

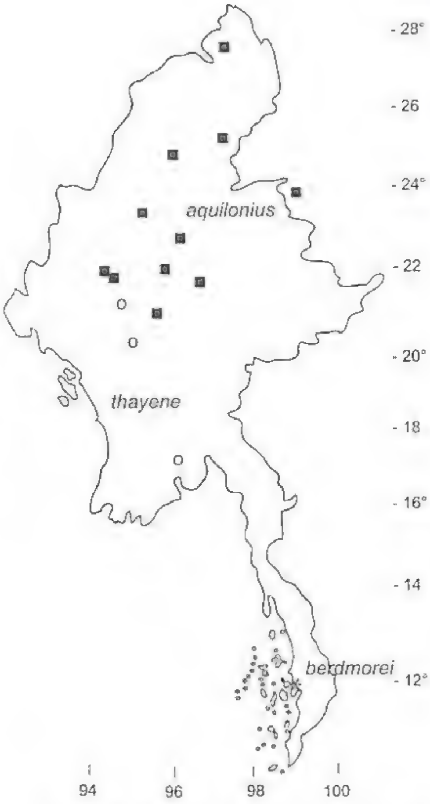


FIGURE 8. Distribution of *Hemidactylus bowringii* group members in Myanmar. *H. aquilonius*, squares; *H. thayene*, circles; *H. berdmorei*, star-burst.

DISTRIBUTION AND NATURAL HISTORY.— *H. aquilonius* occupies the northern half of Myanmar and adjacent western China (Fig. 9). It extends southward east of the Ayeyarwady River to the Mandalay-Bago border, which also roughly marks the southern limits of the Burmese central dry zone.

The habitat data for Yunnan and Kachin indicate that *H. aquilonius* is a house (commensal) gecko. In contrast, all Chatthin specimens were collected in the forest and on the forest floor amongst leaf litter. At Chatthin, *H. frenatus* was major gecko resident of the park headquarter buildings. At Alaungdaw Kathapa, *H. aquilonius* was collected both on buildings and in the forest. The AK collection notes indicate that individuals were found most frequently on bare banks of streams.

## ***Hemidactylus thayene* Zug and McMahan, sp. nov.**

Figures 4, 6, 8.

HOLOTYPE.— USNM 564821, adult male from MYANMAR, **Magway Division**, Shwe-Settaw Wildlife Sanctuary, Namada River bluff at main station (20°03′33″N 94°35′39″E, ~112 m) collected by Sai Wunna Kyi and George R. Zug, 22 February 2003.

PARATYPES.— MYANMAR: **Magway Division**, Shwe-Settaw Wildlife Sanctuary, in or vicinity of – CAS 213598–599, 213603, 213619, 213779, 213782–783, 213835, 213838, 213840, 213845, 213860–861, 213876–878, 213882, USNM 564822–823, 564825–832.

DIAGNOSIS.— *Hemidactylus thayene* is a member of the *H. bowringii* species group and differs from other members of this group by the possession of the following set of traits: adult SVL averaging 38.2 mm (range, 34–44 mm); 6–8 fourth finger lamellae (mean, 6.9); 3–5 of fourth finger lamellae divided (3.9); 7–11 fourth toe lamellae (mean, 9.2); 4–6 of fourth toe lamellae divided (4.6); 18–26 precloacal pores in males (23.1); posterior edge of first and second postmental scales usually transversally straight; dark dorsolateral trunk stripe of short segment transversely elongate; and dorsal surface of tail with dark chevrons with slight or no light posterior border.

ETYMOLOGY.— The name derives from the Burmese word for ghost, *thaye* – pronounced thayay – and *nge* or *ne* for small, hence yielding *thayenge* or *thayene*. The latter is more euphonious and is used as a noun in apposition. The little ghost epithet refers to the light rustling of leaves created by this gecko's nocturnal foraging on the forest floor during the dry season.

DESCRIPTION OF THE HOLOTYPE.— An adult male of 35.4 mm SVL, 15.5 mm TrunkL, 14.2 mm SnForel, 4.5 mm ForeaL, 5.0 mm CrusL, and 30 mm TailL (regenerated). Head pentagonal in outline, snout bluntly pointed, and covered dorsally with small granular scales in juxtaposition: 8.6 mm HeadL, 5.8 mm JawW, 3.6 mm HeadH, 3.5 mm SnEye, 2.7 mm NarEye, 2.3 mm EyeEar, 0.5 mm SnW. Bilateral measurements from right side.

Plate-like head scales confined to margin of mouth; rostral trapezoidal, top edge slightly concave and clefted, bordered behind by 3 internasal scales; 32 interorbital scales; naris surrounded by 3 nasal scales, and rostral; 10/10 (left/right) Suplab, 4/4 Suplab in front of anterior edge of eye; 9/8 Inflab; broad triangular mental scale bordered posteriorly by large 1° postmentals; latter bordered on lateral half by 2° postmental on each side; posterior border of 1° postmental straight 2° postmental about half area of 1° postmental, left and right postmentals equal sized.

Body slightly depressed, moderately robust, covered by small, smooth granular scales dorsally and laterally; scale size increasing gradually from middorsally to ventrolaterally and more abruptly to ventral scales; ventral scales several times larger than dorsal scales, smooth plate-like and slightly overlapping; approximately 96 scales around midbody; slight ventrolateral fold on trunk. Tail ellipsoidal in cross-section, segmented; small granular scales dorsally, gradually enlarging laterally to become cycloid ventrolaterally onto ventral surface, and ventromedially large rectangular and slightly overlapping; ventrolateral fringe barely evident although enlarged blunt scale on each side at posterior end of segment. Limbs well-developed; all digits well-developed, each bearing a claw and digital pad with rectangular lamellae, 7/7 4FingLm, 3/4 4FingDv, 10/10 4ToeLm, 5/5 4ToeDv. Femoral and precloacal pores (10/11) continuous on right, separated medially by 3 nonpore scales.

Coloration in preservative tannish ground color with brown markings. Dorsally head lightly speckled with tiny brown spots, brown spots dorsally on neck, trunk and tail; brown spots bordered posteriorly by white spots; dorsolaterally dark spots widely separated, midlaterally series of white spots not creating stripe; dark lateral stripe from mid-snout through eye and above ear and faintly to axilla. Venter from chin onto tail unicolor white.

INTRASPECIFIC VARIATION.— The regional variation of *H. thayene* is described in the preceding Results and Discussion sections as the samples from Shin-Ma-Taung, Shwe-Settaw, and Yangon (or southern samples). Briefly, adult size ranges from 34 to 44 mm SVL (Table 5), and most other body metrics are strongly correlated to SVL. Shwe-Settaw has the smallest average adult size (37.5 mm SVL), Yangon individuals are only slightly larger, and Shin-Ma-Taung *H. thayene* are the largest. Scalation is generally similar (Table 4) in the three samples. Shin-Ma-Taung geckos have the lowest values for most scalation traits, although the ranges of these traits typically overlap broadly.

An adult male from Shwe-Settaw (USNM 564824; 41.1 mm SVL) possesses *H. aquilonius* scalation characteristics. Most striking is the 30 TotPore value, shared only with Yunnan sample geckos. Other scalation features are at the higher end of the range for the three *H. thayene* samples. This specimen was either preserved in the light phase, or if in the dark phase, its coloration is nearly unicolor. We have tentatively identified it as a *H. aquilonius*. Because a tissue sample was obtained when originally collected, our identification can be tested.

**Distribution and natural history.**— *H. thayene* occurs from south-central Magway southward to the Ayeyarwady delta (Yangon area) (Fig. 9).

Field notes suggest that *H. thayene* is a forest-floor resident. It was found either at night moving among the leaf litter or during the day beneath litter such as logs and rocks.

## Key to *Hemidactylus* in Myanmar

1a. Dorsally trunk with uniform scalation of small, nearly equal-sized granular scales .......2
1b. Dorsally trunk with enlarged smooth or keeled tubercles variously arranged among small granular scales ........................................................5

2a. Adults ≥ 49 to ≤ 68 mm SVL. Secondary postmental scales separated from infralabial scales by one or two rows of small chin scales. Ten to 15 subdigital lamellae on fourth toe of each hindfoot; all lamellae, except terminal one, clefted or divided. Tail strongly dorsoventrally depressed,spindle-shape in cross-section, and with ventrolateral sawtooth-like fringe of pointed scales, largest one at posterior margin of each tail segment ...............*H. garnotii*
2b. Adults ≥ 34 to ≤ 58 mm SVL. Secondary postmental scales touch infralabial scales. Six to 11 subdigital lamellae on fourth toe of each hindfoot;some proximal and terminal lamellae entire, mid-digit ones clefted or divided. Tail strongly or weakly depressed, spindle-shape or oblong in cross-section, and ventrolateral fringe present or absent..........................3

3a. Adults ≥ 47 to ≤ 58 mm SVL. Well-developed skin fold ventrolaterally on trunk and rear of thigh. Webbing between digits of fore- and hindfeet ¼–⅓ length of digit. Tail strongly dorsally depressed, spindle-shape in cross-section, and with ventrolateral fringe of densely packed enlarged scales. Adult males with 36–40 precloacal-femoral pores ..........*H. platyurus*
3b. Adults ≥ 34 to ≤ 56 mm SVL. No or weak skin fold ventrolaterally on trunk. Webbing between digits of fore- and hindfeet, if present, limited to base of digits. Tail depressed, oblong in cross-section, without distinct ventrolateral fringe of scales. Adult males with 18–32 precloacal-femoral pores ....................................*H. bowringii* species group 4

4a. Adults ≥ 39 to ≤ 56 mm SVL. Posterior edge of first postmental scales usually angularly convex. Adult males with 21–32 precloacal-femoral pores, usually ≥ 26. Dark dorsolateral trunk stripe of elongate dash-like spots; dorsal surface of tail with small, irregular dark spots rarely bordered by white .........................................*H. aquilonius* sp. nov.
4b. Adults ≥ 34 to ≤ 44 mm SVL. Posterior edge of first and second postmental scales usually transversally straight. Adult males with 18–26 precloacal-femoral pores, usually ≤ 24. Dark dorsolateral trunk stripe of short segment transversely elongate; dorsal surface of tail with dark chevrons with slight or no light posterior border ...................*H. thayene* sp. nov.

5a. Adults ≥ 42 to ≤ 59 mm SVL. Dorsally and laterally trunk with six or fewer longitudinal rows of small, widely spaced, smooth tubercles. Tail robust, oblong in cross-section, and strongly segmented; each segment with 6 (usually) enlarged, projecting cone-like scales along posterior border.Adult males with 23–34 (usually ≥ 29) precloacal-femoral pores . . . . . .*H. frenatus*

5b. Adults ≥ 38 to ≤ 65 mm SVL. Dorsally and laterally trunk densely covered with smooth or keeled tubercles. Tail robust and strongly segmented with whorl of spiky scales or slightly depressed and modestly segemented with narrow ventrolateral fringe of scales . . . . . . . . . .6

6a. Adults ≥ 45 to ≤ 65 mm SVL. Dorsally and laterally trunk with 14 to 16 longitudinal rows of slightly keeled tubercles. Tail robust, oblong in cross-section, and strongly segmented; each segment with whorl of 8 (usually) spiky scales in middle of segment. Adult males with 11-16 precloacal-femoral pores, each side widely separated medially . . . . . . . . . . . . . . . .*H. brookii*

6b. Adults ≥ 46 to ≤ 56 mm SVL. Dorsally and laterally trunk with numerous scattered smooth tubercles, not arranged in rows. Tail moderately depressed, flatten spheroid in cross-section and distinctly segmented with narrow ventrolateral fringe of flattened, pointed scales, largest scale at posterior edge of each segment. Adult males with 26-38 (usually ≥ 34) precloacal-femoral pores, narrowly separated medially . . . . . . . . . . . . . . . . . . . . . . . . . . . .*H. karenorum*

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# Appendix

## A. Definition of Morphological Characters

Each character and its abbreviation follow. Abbreviations follow Zug et al. (2003) for ease of recognition. All bilateral characters reported for right side, all measurements in millimeters.

### MENSURAL CHARACTERS:

Crus length: **CrusL**—Length of tibia from knee to heel.
Forearm length: **ForeaL**—Length of ulna from elbow to wrist.
Eye-ear length: **EyeEar**—Distance from posterior edge of orbit to anterior edge of ear-opening.
Head height: **HeadH**—Dorsoventral distance from the top of head to the underside of the jaw at the transverse plane intersecting the angle of jaws.
Head length: **HeadL**—Distance from tip of snout to anterior edge ear-opening.
Jaw width: **JawW**—Straight-line distance from left to right outer edge of jaw angles; this distance does not measure the jaw musculature broadening of the head.
Nares-eye length: **NarEye**—Distance from nares to anterior edge of orbit.
Snout-eye length: **SnEye**—Distance from tip of snout to anterior edge of orbit.
Snout-forelimb length: **SnForel**—Distance from tip of snout to anterior border of forelimb insertion.
Snout-vent length: **SVL**
Snout width: **SnW**—Distance across snout between left and right nares.
Trunk length: **TrunkL**—Body length or axilla-groin length of others; distance between the posterior edge of the forelimb insertion (axilla) to the anterior edge of the hindlimb insertion (inguen).

### MERISTIC CHARACTERS:

Chin (postmental) scales: **Chin**—Medial contact of paired postmental scales.
Chin scale size: **ChinSD**—Size of enlarged or primary postmental scales relative to secondary postmentals.
Asymmetrical chin shield: **ChinSAs**—Comparative size of primary postmental scales, right to left one.
Infralabials: **Inflab**—Number of enlarged scales bordering the mouth from mental to below posterior border of eye.
Naris-infralabial contact: **NaInf**—Naris abuts or separated from first supralabial.
Snout scales: **SnS**—Number of scales between left and right nares and touching rostral.
Subcaudal scales: **Subcaud**—Size of median subcaudal scales relative to adjacent caudal scales.
Supralabials: **Suplab**—Number of enlarged scales bordering the mouth from the rostral to below the posterior border of eye.
Total pores: **TotPore**—Total number of femoral and precloacal pores.
Fourth finger lamellae (scansors): **4FingLm**—Nuimber of 4th digit lamellae; usually lamellae extend from distal tip of digit to the base of the digit at its intersection with palm. Count includes the distalmost, unpaired lamellae of digital pad.
Fourth finger lamellae divided: **4FingDv**—Number of paired or divided 4th finger lamellae.
Fourth toe lamellae (scansors): **4ToeLm**—As for 4FingLm.
Fourth toe lamellae divided: **4ToeDv**—Number of paired or divided 4th toe lamellae.

## B. Specimens Examined

Samples are arranged roughly from north to south and east to west, and identified by the locality name used in the text. Some samples are composites. Precise locality data are available from the electronic databases of the California Academy of Sciences' (CAS) and the Smithsonian Institution-National Museum of Natural History's (USNM) webpages.

**CHINA: Yunnan** *Hemidactylus aquilonius*. Liuku – CAS 207461–462, 207464, 207466, 215039, 215041–042, 215045–048, 228103–104, 228107–109.

**MYANMAR: Kachin** [Kachin State] *Hemidactylus aquilonius*. Putao – CAS 221204–205, 221208, USNM 564840; Machanbaw – 230218; Pidaung Wildlife Sanctuary – CAS 230368, 230371–374; He Pu village – CAS 232810–811, 232882, 232884, 233000, 233019. **Sagaing** [Sagaing Divis.] *Hemidactylus aquilonius*. Alaungdaw Kathapa Natl. Park, in or vicinity of – CAS 206649, 215444, 215519, 215759, 215777, USNM 564841–842; Chatthin W.S. – USNM 520552–056, 537425–426; Pale – CAS 215434, 215437; Sweekawngan village – CAS 232243–244. **Mandalay** [Mandalay Divis] *Hemidactylus aquilonius*. Kyidaunggan – CAS 206504; Tha Pyaew village – 208455–456, 208458, 208460; Popa Mountain Park, in or vicinity of – 213956, 215827, 231322; Min-Gon-Taung Wildlife Sanctuary, in or vicinity of – 215945, 216029, 216068, 231394, 231454; Shwe-U-Daung Wildlife Wildlife Sanctuary, in or vicinity of – CAS 216133, 216345 [Shan State]; Pyin-Oo-Lwin, vicinity of – USNM 564845-849. **Shin-Ma-Taung** [Magway Divis.] *Hemidactylus thayene*. Shin-Ma-Taung Wildlife Sanctuary, in or vicinity of – CAS 215841, 215843–844, 215846, 215848, USNM 564833–834. **Shwe-Settaw** [Magway Divis.] *Hemidactylus thayene*. Shwe-Settaw Wildlife Sanctuary, in or vicinity of – CAS 213598–599, 213603, 213619, 213779, 213782–783, 213835, 213838, 213840, 213845, 213860–861, 213876-878, 213882, USNM 564821–823, 564825–832. **Yangon** [Yangon Divis.] *Hemidactylus thayene*. Hlawga Wildlife Park – CAS 213320, 213333, 213428, 230426.

**CHINA: Hong Kong** *Hemidactylus bowringii*. MCZ R172987, R172989, R172991, R172994–995, R172999–3000, R173003, R173005, R173011.

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# Calcaxonian Octocorals (Cnidaria; Anthozoa) from Eastern Pacific Seamounts

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**Eleven calcaxonian gorgonians are reported from seamounts in the Northeast Pacific, including eight new records for this region, six of which are described as new species. Twenty-one calcaxonians are now known from the Northeast Pacific (exclusive of Alaska). A table of comparisons is given for all six species of *Parastenella* and the three eastern Pacific species of *Calyptrophora*. A neotype is designated for *Chrysogorgia fruticosa*.**

Calcaxonian octocorals (those species belonging to the five families Chrysogorgiidae, Primnoidae, Isididae, Ifalukellidae, and Ellisellidae) appear to be one of the few monophyletic groups within the octocorals, supported by both morphological (Grasshoff 1999) and molecular (McFadden et al. 2006) characters. Five hundred fifty-two of the approximately 3100 known octocoral species (17%) are calcaxonians, most of those occurring in deep water. However, surprisingly few have been reported from the Northeast Pacific, a review of the literature revealing only 13 species. Over half of those species were reported by Studer (1894) from tropical East Pacific localities, such as the Galápagos and the Gulf of Panama; those and the reminder are listed in Table 1. In this paper eight new records (including six new species) and three additional records of previously reported species are reported, raising the number of Northeast Pacific calcaxonians to 21 species. Judging from additional unidentifiable fragmentary material, there would appear to be more deep-water species from these East Pacific seamounts.

## MATERIALS AND METHODS

Most of the specimens reported herein resulted from collections made in 2006 on seamounts off Washington, Oregon, and California by MBARI staff using the ROV *Tiburon*. Additional specimens were donated by James Boutillier (Pacific Biological Station, Nanaimo) from seamounts off British Columbia, and by Amy Baco (WHOI) from Alaskan seamounts.

Abbreviations used in the text include: BM – The Natural History Museum, London; JD – *Jason II*; L:D – length to diameter ratio of cylindrical sclerites; L:W – length to width ratio of flattened sclerites; CAS – California Academy of Sciences, San Francisco, California; MBARI – Monterey Bay Aquarium Research Institute, Moss Landing, California; MBNMS – Monterey Bay National Marine Sanctuary; MCZ – Museum of Comparative Zoology, Harvard College, Cambridge, Massachusetts; T – ROV *Tiburon*; USNM – United States National Museum, Washington, D.C., now the National Museum of Natural History; WHOI – Woods Hole Oceanographic Institute, Woods Hole, Massachusetts; YPM – Yale Peabody Museum, New Haven, Connecticut; ZMA – Zöologisch Museum, Amsterdam, Netherlands.

TABLE 1. Calcaxonian octocorals known from the eastern Pacific north of the Equator (exclusive of Alaska).

| Name | Reported by | East Pacific Distribution |
|---|---|---|
| **Family Chrysogorgiidae** | | |
| *Chrysogorgia fruticosa* (Studer, 1894) | Studer (1894), herein | Gulf of Panama, off Pacific Mexico |
| *C. pinnata*, sp. nov. | herein | Davidson Seamount |
| *C. monticola*, sp. nov. | herein | off California and Washington |
| *Iridogorgia* sp. | herein | Davidson Seamount |
| **Family Primnoidae** | | |
| *Amphilaphis abietina* Studer, 1894 | Studer (1894) | off Ecuador |
| *Callogorgia flabellum* (Ehrenberg, 1834) | Studer (1894) | Gulf of Panama, off Pacific Mexico |
| *C. kinoshitae* Kükenthal, 1913 | Kükenthal (1913) | off California |
| *C. sertosa* (Wright & Studer, 1889) | Nutting (1909) | off California |
| *Calyptrophora agassizii* Studer, 1894 | Studer (1894) | Galápagos |
| *C.* sp. cf. *C. antilla* Bayer, 2001 | herein | Davidson Seamount |
| *C. bayeri*, sp. nov. | herein | Davidson Seamount |
| *C. laevispinosa*, sp. nov. | herein | off Washington |
| *Narella ambigua* (Studer, 1894) | Studer (1894) | Galápagos |
| *N. bowersi* (Nutting, 1908) | Cairns & Bayer (2007), herein | off British Columbia and Washington |
| *Parastenella gymnogaster*, sp. nov. | herein | Oregon to Alaska |
| *P. pacifica*, sp. nov. | herein | Oregon to British Columbia |
| *P. ramosa* (Studer, 1894) | Studer (1894), herein | Panama to Alaska |
| *Plumarella longispina* Kinoshita, 1908 | Nutting (1909) | off California |
| *Primnoa pacifica* Kinoshita, 1907 | Cairns & Bayer (2005) | California to Alaska |
| *P. pacifica willeyi* Hickson, 1915 | Hickson (1915) | off British Columbia |
| **Family Isididae** | | |
| *Lepidisis evalinae* Bayer, 1989 | Bayer (1989) | Galápagos |
| *L. inermis* Studer, 1894 | Studer (1894) | off Pacific Colombia |

## SYSTEMATIC TREATMENT

### Subclass Octocorallia
### Order Gorgonacea
### Suborder Calcaxonia Grasshoff, 1999
### Family Chrysogorgiidae Verrill, 1883

### *Chrysogorgia* Duchassaing and Michelotti, 1864

TYPE SPECIES.— *Chrysogorgia desbonni* Duchassaing and Michelotti, 1864, by monotypy.

DIAGNOSIS.— Branching from main branch sympodial in an ascending spiral (clockwise or counterclockwise) producing a bottlebrush colony, or dichotomous in one or more planes. Branchlets repeatedly and dichotomously branched; terminal branchlets short. Polyps large in relation to branch and well separated. Sclerites consist of spindles, rods, and scales. Axis with a brilliant metallic luster, usually golden or yellow in color.

REMARKS.— The 59 valid species of *Chrysogorgia* are listed by group in Cairns (2001); only one species has been described subsequently (Cairns 2002).

In addition to the two species reported below, additional fragments of three *Chrysogorgia* species from San Juan Seamount (1972 m), Gorda Seamount (3169 m), and Vance F Seamount (2280 m) were collected but could not be identified due to their fragmentary nature, but each may well represent an undescribed species. The chrysogorgiid *Iridogorgia* was also common on Davidson Seamount; these specimens are being examined by Les Watling.

DISTRIBUTION.— Known from all ocean basins at depths of 100–3375 m.

***Chrysogorgia pinnata*** **Cairns, sp. nov.**
Figures 1D, 2.

**Material Examined.**— Types.

**Types and Type Locality.**— Holotype: T947-A5, 35°37.6′N, 122°50.1′W (Davidson Seamount, California), 3114 m, 1.64°C, 1 February 2006, 1 colony in a dozen fragments, SEM stubs 1274–1275, USNM 1102450, and one fragment (CAS 175303). Paratype: T1012-A16, 45.633°N, 130.664°W (Vance B Seamount off Oregon), 1969 m, 3 August 2006, 1.91°C, 1 branch, USNM 1102451.

**Description.**— The holotype was badly damaged in collection, now consisting of over a dozen fragments, the largest 13 cm wide and 6 cm tall (Fig. 1D); the complete colony is estimated to have been about 20 cm tall and equally broad; the base of attachment was not collected. The *in situ* photograph (Fig. 1G) taken prior to collection shows the colony to have consisted of about 13–15 main branches, all united near the base, the branches roughly aligned in one plane. The main branches of the colony are regularly (every 3.0–3.5 mm) and pinnately branched, the main branches bending in a slightly sympodial manner. The branchlets diverge in an alternating opposite fashion and are straight for about 3–4 cm and bear 4 or 5 polyps, after which they terminate or continue to branch in a dichotomous fashion. On either side of a main branch the branchlets are uniformly parallel to one another. The largest branch axis is 1.4 mm in diameter, branchlet axes being only 0.15 mm in diameter, which produces relatively firm colony support and yet flexible branchlets. The main axis has a metallic dull golden luster.

The polyps are elongate, up to 2.8 mm in length and 0.8 mm in diameter, and well spaced on the branchlets, separated from one another by 4–5 mm. They attach perpendicular to the branchlets (rarely on main branches) and often are oriented downward. Some polyps bear 1–3 globular masses, each up to 1 mm in diameter (Figs. 2D–E), at the base of the polyp and extending to the far side of the branchlet, these assumed to be reproductive pouches. The body wall of the polyp is covered with longitudinally oriented, elongate rods that have flattened tips (Fig. 2A), these rods being 0.27–0.56 mm in length and 0.018–0.036 mm in width (L:W = 10.7–16.7). They are grouped into 8 longitudinal cords along the body wall, which continue apically to support the 8 tentacles, the rods diminishing only slightly in length in the tentacles (about 0.21 mm). These flattened rods are sparsely covered with small (2–3 μm tall), irregularly-shaped granules (Fig. 2C). No specialized tentacular or pinnular sclerites were noted. Toward the base of the polyp and covering the reproductive pouches, as well as the coenenchyme, the sclerites consist of scales (Fig. 2B) 0.135–0.23 mm in length and 0.030–0.046 mm in width ( L:W = 3.2–5.4) that are arranged in a random order. The faces of these scales are relatively smooth (i.e., only crystal structure visible), their edges finely serrate. Most sclerites are translucent.

**Comparisons.**— The 59 valid species of *Chrysogorgia* are divided into three groups depending on whether a species has spindles/rods or scales in their body wall and tentacles (see Cairns 2001). Whereas *C. pinnata* has well-defined scales in the coenenchyme, the sclerites in the body wall and tentacles are elongate flattened rods with even more flattened tips — a blend of rod and scale characteristics, but perhaps closer to being a rod. This would place it in Group A ("Spiculosae" *sensu* Wright and Studer 1889), which includes species having rods/spindles in both body wall and tentacles. The unique nature of the sclerites in *C. bipinnata* distinguishes it from all other species in that group. Another way to compare this species with others is that it has a flabellate colony. Only six other *Chrysogorgia* species have a flabellate colony: *C. curvata* Versluys, 1902; *C. chryseis* Bayer and Stefani, 1988, *C. stellata* Nutting, 1908; *C. electra* Bayer and Stefani, 1988; *C. scintillans* Bayer and Stefani, 1988; and *C. desbonni* Duchassaing and Michelotti, 1864. *Chrysogorgia pinnata* differs from these species in having pinnate branching; the others are dichotomously branched.

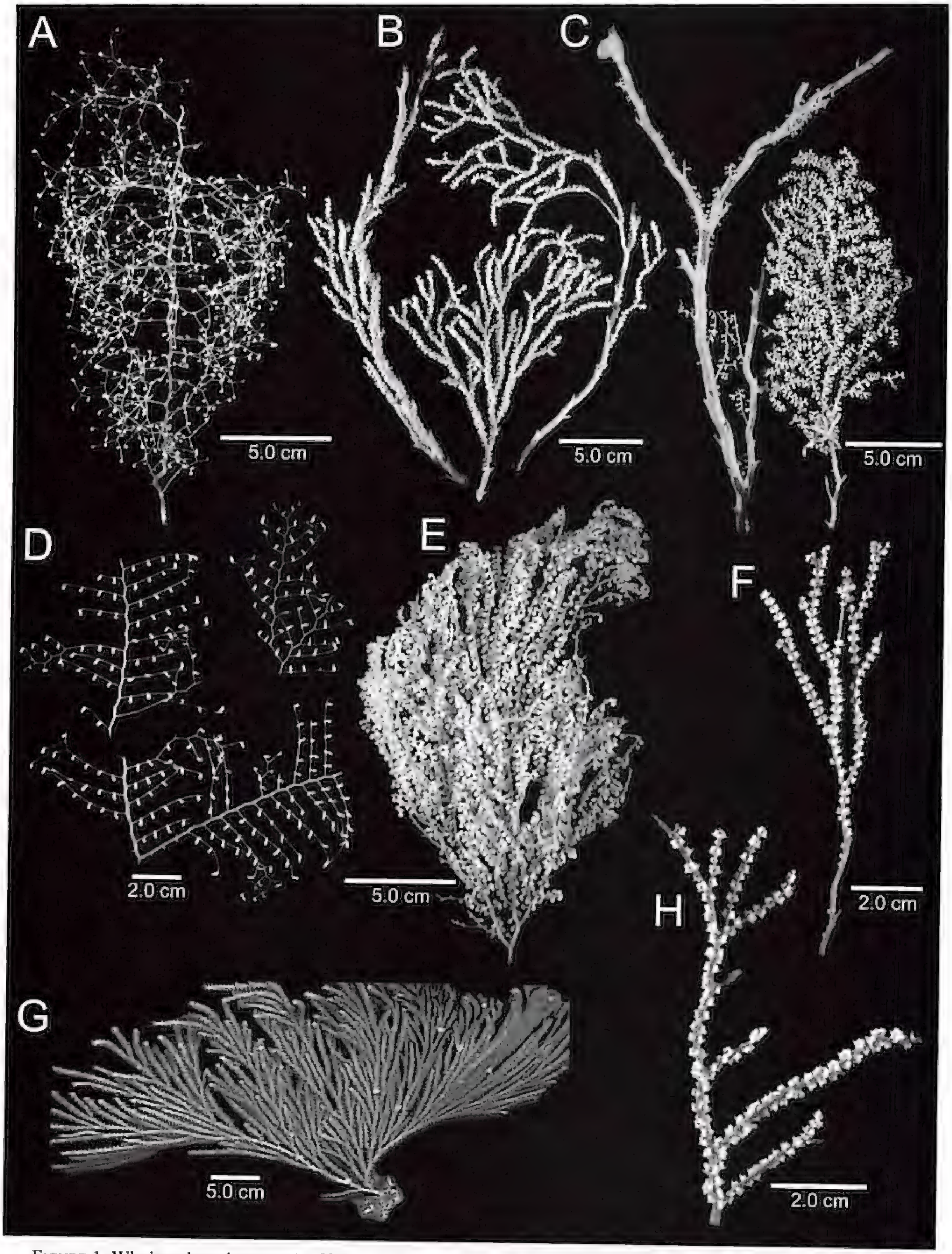

FIGURE 1. Whole colony images: A. *Chrysogorgia monticola*, largest fragment of the holotype. B. *Paragorgia gymnogaster*, three large fragments of the holotype. C. *Parastenella pacifica*, two fragments of the holotype. D. *Chrysogorgia pinnata*, three fragments of the holotype. E. *Parastenella ramosa* from T874-A6 (USNM 1102456). F. *Calyptrophora* sp. cf. *C. antilla*, branch fragment from T943-A3 (USNM 1102459). G. *In situ* photograph of holotype of *Calyptrophora laevispinosa*. H. *Calyptrophora bayeri*, fragment of the holotype. Scale bars: A–C, E, G, 5 cm; D, F, H, 2 cm.

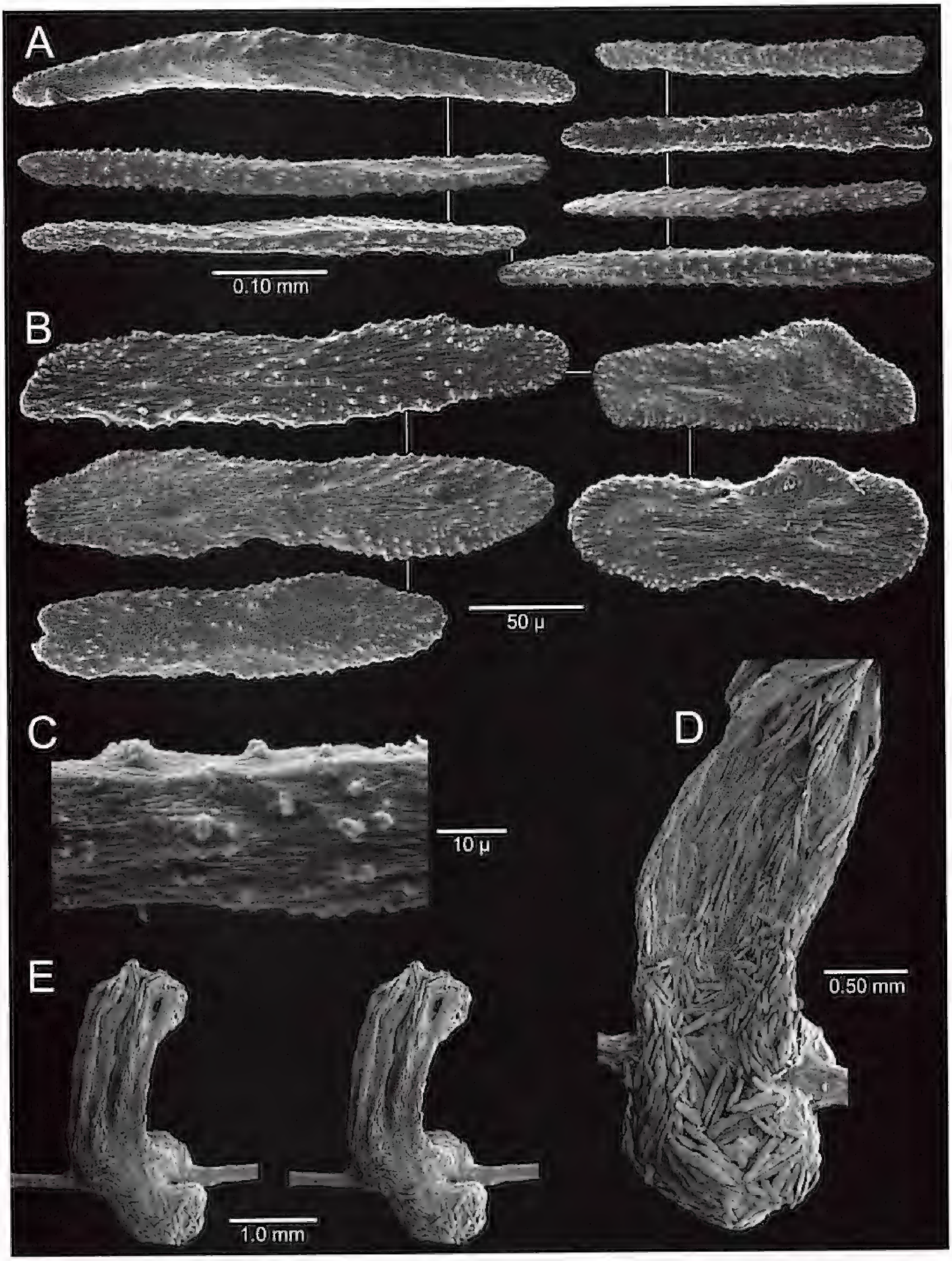

FIGURE 2. Sclerites from holotype of *Chrysogorgia pinnata:* A. Seven flattened body wall rods. B. Five coenenchymal scales. C. Enlargement of the mid-section of a body wall rod. D. Lateral view of a polyp with a basal brood chamber. E. Stereo lateral view of a polyp with a brood chamber. Scale bars as indicated on figure.

**Etymology.**— The species was named (Latin *pinnatus* = feathered, pinnate) for the pinnate arrangement of its branches.

**Distribution.**— Davidson and Vance Seamounts off California and Oregon; 1968–3114 m. Based on 70 observations, Lonny Lundsten (pers. comm.) has recorded this species from Davidson Seamount from depths of 1968–3275 m (most between 2600–3100 m) and at temperatures of 1.64–1.91°C (most between 1.65–1.75°C).

### *Chrysogorgia monticola* Cairns, sp. nov.

Figures 1A, 3.

**Material examined.**— Types.

**Types and type locality.**— Holotype: T945-A8, 35°49.4′N, 122°36.5′W (Davidson Seamount, California), 2662 m, 1.76°C, 30 January 2006, 1 colony now in 4 pieces and SEM stubs 1204–1208, 1276, USNM 1102452, and 1 piece at CAS 175304.

**Description.**— The colony is bottlebrush-shaped, the holotype colony being 19 cm tall and 10 cm wide, with a basal branch diameter of 1.55 mm; a holdfast was not present. The branching sequence is 1/3R, *i.e.*, there are three longitudinal rows of branchlets that diverge perpendicular to the main branch, every third branch aligned with one above and below, and the branches appear to spiral upward in a counterclockwise manner when viewed from above, thus the R (right) designation. Branchlets originate every 4–5 mm from the main branch, each dichotomously branching up to 5 or 6 times (having 5–6 nodes); the branching axils are about 45°. The first internode of a branchlet is about 12 mm long, but successive internodes are 7–8 mm in length, resulting in a fully developed branchlet length up to 5 cm. Each internode bears only 1or 2 polyps, the polyps spaced 3.5–4.0 mm apart. The diameter of a distal branchlet is only 0.1 mm. The axis is metallic gold.

The polyps are rather stout (Fig. 3F), about 1.1 mm tall and 1.0 mm in distal diameter, rarely preserved with their tentacles expanded; a basal swelling was not observed. The body wall and axis of the tentacles are protected by longitudinally oriented flattened rods that have blunt, pleated, and even more compressed tips (Figs. 3A, E). Most of the body wall sclerites are 0.27–0.37 mm in length and 0.050–0.080 in width (L:W=5.5–10.5) but some may be as long as 0.65 mm; their surfaces are smooth or sparsely granular. The base of each tentacle appears to have 1 or 2 large rotund rods that are often irregular in shape, having multiple tips and side projections (Fig. 3B); they measure 0.45–0.65 mm in length and 0.10–0.16 mm in diameter (L:W=3.3–5.0). The tips of the tentacles are covered by small, crescent-shaped pinnular scales (Fig. 3D), which, like the body wall sclerites, have blunt, pleated tips. These scales are 0.072–0.25 mm in length and 0.035–0.050 in width (L:W=4.0–5.5), their size decreasing distally. The coenenchymal sclerites (Fig. 3C) are thin elongate scales 0.170–0.375 in length and 0.032–0.080 mm in width (L:W=5–7), having blunt tips, a coarsely irregular margin, a sparsely granular outer surface, and a smooth crystalline inner surface.

**Comparisons.**— Like *C. pinnata*, the body wall sclerites of *C. monticola* are flattened rods (not scales), and some of the tentaculars are rotund rods, which places this species in Group A of *Chrysogorgia*. One of the unique characteristics of the species of *Chrysogorgia* is its variety of formulaic branching sequence (see Versluys 1902, Cairns 2002), some of the most common being 2/5R (16 species), 1/4L (13 species), and 1/3L (9 species), although other sequences include: 2/5L, 1/4R, 1/5R, 1/6R, 1/7R, and several species are flabellate with purely dichotomous branching. Thus, the 1/3R branching sequence of *C. monticola* is unique in the genus.

Only one previously described species of *Chrysogorgia* is known from the eastern Pacific, *C. fruticosa* (Studer, 1894), previously reported only from the Bay of Panama at 837 m (*Albatross*

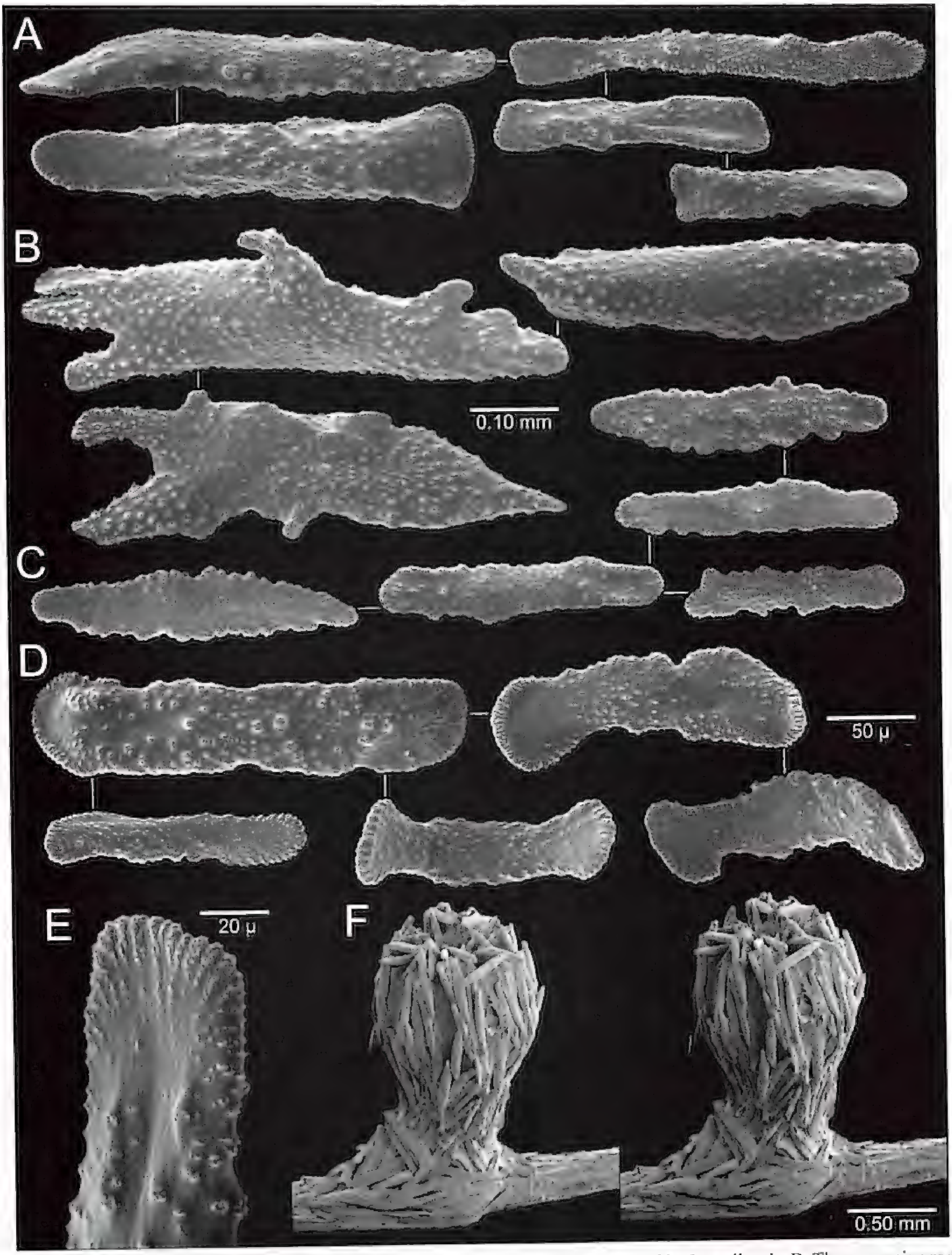

FIGURE 3. Sclerites from holotype of *Chrysogorgia monticola*: A. Five flattened body wall rods. B. Three massive rods in base of calyx. C. Smooth coenenchymal scales. D. Curved pinnular scales. E. Flattened and pleated tip of a body wall rod. F. Stereo view of a polyp. Scale bar for A–C, 0.1 mm; D, 50 µm; E, 20 µm; F, 0.5 mm.

station 3384, not "7,907" as indicated by Studer). It also has a 1/3 branching sequence but whether sinistral (L) or dextral (R) is unknown, as the original description is inadequate and unillustrated, and the type, which should be deposited at the MCZ (the types of 6 of 19 new species from this paper are at the MCZ), was not present in 2006. Nor is the type deposited at the YPM (Lazo-Wasem, pers. comm), where parts of many of verrill's octocoral types are deposited. Thus, in order to define *C. fruticosa* and to distinguish it from other species, a neotype was chosen (USNM 98799), collected off Pacific Mexico (*Atlantis II*, AD3016: 12°43′12"N, 102°36′W, "Seamount 6", 500 km off Acapulco, Mexico) at 1900–1950 m. This specimen, although somewhat larger than the type (30 cm in height) and collected farther to the north and at a greater depth than the type, agrees with all the characteristic mentioned by Studer in his original description. It differs from *C. monticola* in having a branching formula of 1/3L and in having exclusively irregularly-shaped scales (0.25–0.35 mm in length) in its polyps, tentacles, and coenenchyme, which places it in Group C, not Group A, as for *C. monticola*.

Etymology.— The species name (Latin *mont* = mountain + *-cola* = dweller), literally mountain dweller, is an allusion to its habitat on seamounts.

Distribution.— Davidson Seamount off California. Based on 110 observations, Lonny Lundsten (pers. comm.) has recorded this species from Davidson Seamount from depths of 1711–3015 m (most between 2400–2500 m) and at temperatures of 1.66–2.38°C (most between 1.74–1.84°C). Thus, *C. monticola* is generally found in slightly shallower and warmer water than *C. pinnata*.

## Family Primnoidae Gray, 1858

### *Parastenella* Versluys, 1906

Type species.— *Stenella doederleini* Wright and Studer, 1889.

Diagnosis.— Colonies flabellate, slightly bushy, or irregularly branched. Calyces occur in whorls, pairs, or individually, oriented perpendicular to branch. Body wall scales arranged in 5–8 longitudinal rows, the 8 marginal scales elongate and usually fluted, offset in alignment from opercular scales. Opercular scales roughly equal in size, with a highly keeled inner surface.

Remarks.— The six species of *Parastenella* are compared in Table 2.

Distribution.— Known from all ocean basins except the eastern Atlantic (Cairns 2007) at depths of 567–3470 m.

### ***Parastenella ramosa*** **(Studer, 1894)**

Figures 1E, 4, 5.

*Stenella ramosa* Studer, 1894:64–65.
?*Stenella doederleini*.–Studer, 1894:64 (Pacific Panama, 1429 m).
*Stenella* (*Parastenella*) *ramosa*.–Versluys, 1906:47–48. Kükenthal, 1919:445; 1924:303.

Material examined.— *Gilliss*-21, 7°11′N, 79°16′W, 1463 m, 18 January 1972, 1 colony, USNM 57554; T628-A12, 34°03′06″N, 121°03′00″W (Rodriguez Seamount, California), 665 m, 5.1°C, 13 October 2003, 2 colonies, USNM 1027058; T631-A4, 34.04°N, 121.04° W (Rodriguez Seamount, California), 735 m, 4.94°C, 16 October 2003, 1 colony, USNM 1102453; T941-A4, 35.72°N, 122.72°W (Davidson Seamount, California), 1310 m, 2.96°C, 27 June 2006, 1 branch, USNM 1102454; T833-R56, 36.84°N, 122.51°W (Monterey Bay, California), 1717 m, 2.28°C, 15 March 2005, 1 bushy colony, USNM 1102455; T874-A6, 45.87°N, 129.99°W (Axial 1998 South Flow, Washington), 1702 m, 2.17°C, 8 August 2005, 1 colony and SEM stubs 1277–1280, USNM 1102456, and 1 colony, CAS 175305; *WE Ricker*, Tow 25 (#137), 52°01′39″N, 131°35′37″W (off British Columbia), 1563–1776 m, 5 September 2004, 1 colony, USNM 1094072; *WE Ricker*, Tow 31, 52°42′09″N, 132°26′00″W (off British Columbia), 819–936 m, 7 September 2004, 1 colony,

TABLE 2. Characteristics of the six species of *Parastenella*.

| | *P. ramosa* (Wright & Studer, 1889) | *P. doederleini* (Wright & Studer, 1889) | *P. gymnogaster*, sp. nov. | *P.pacifica*, sp. nov. | *P. atlantica* Cairns, 2007 | *P. spinosa* (Studer, 1894) |
|---|---|---|---|---|---|---|
| Colony shape | Usually uniplanar, rarely bushy | Uniplanar to slightly bushy | Uniplanar | Uniplanar | Uniplanar to slightly bushy | Uniplanar to slightly bushy |
| Arrangement of calyces | Singles, pairs, and whorls of 3; directed downward | Whorls of 3 or 4; perpendicular to branch | Singles, pairs, and whorls of 3; strongly curved downward | Singles, pairs, and whorls of 3; perpendicular to branch | Singles, pairs, and whorls of 3 or 4; perpendicular to branch | Singles and occasional pairs; perpendicular to branch |
| Symmetry of marginal scales | Adaxial scales smaller and w/o flutes | 1-3 adaxial marginals smaller and w/o flutes | Adaxial scales smaller and w/o flutes | Uniform | Uniform | Uniform |
| Marginal flutes: shape; % of length | Narrow, tubular; 38-46% | Very narrow, tubular; up to 55% | Broad; 20-25% | Broad, shallow; 30-40% | Broad, shallow; 20-30% | Short and narrow; 22% |
| Submarginal body wall scales: number of rows; scales per row | 5 rows; 2-3/ row, alternating | 5 rows; 3-4/row, alternating | 6 rows; 4-6/abaxial row, linearly arranged | 8 rows; 3-4/abaxial row, alternating | 8 rows; 3-5/row, alternating | 5 rows (2 wide abaxial, 3 smaller adaxial) ; 3-4/row |
| Submarginal abaxial body wall scale flutes | Present | Present | Present | Absent | Occasionally present | Present |
| Adaxial side of body wall | Covered | Covered | Naked basally | Covered | Covered | Covered |
| Coenenchymal scales: shape; outer surface | Irregular, flat; granular | Irregular, flat, granular, rounded knobs centrally and peripherally | Elliptical, concave, ornately ridged | Elliptical, concave, ridged | Elliptical, highly concave, granular | Unknown |
| Pinnular scales | Up to 0.14 mm; L:D = 10-11 | Up to 77 µm; L:D = 5 | Up to 97 µm; L:D = 6-8 | Up to 0.105 mm; L:D = 6 | Rare: up to 82 µm; L:D = 5-7 | Up to 0.10 mm; L:D = 7-10 |
| Distribution and depth | Panama to Gulf of Alaska, 665-1750 m | Japan, Indonesia, 732-3427 m | Oregon to Aleutian Islands, 1962-2773 m | Oregon to British Colombia, 1527-1986 m | New England Seamounts, 1984 m | Prince Edward Islands, 567 m |

USNM 1094071; *WE Ricker*, Tow 32 (#209), 52°41′53″N, 132°32′35″W (off British Columbia), 1750–1860 m, 7 September 2004, 1 colony, USNM 1094057; *WE Ricker*, Tow 28 (#7), 48°19.947′N, 126°23.746′W (off Vancouver Island, British Columbia), 1168 m, 3 September 2001, 4 colonies, USNM 1007336; *Alvin* 4031-6, 54°30′51″N, 136°54′33″W (Dickens Seamount, Gulf of Alaska), 850 m, 7 August 2004, 6 colonies, USNM 1075364; *Alvin* 4032-2, 55°03′10″N, 140°18′32″W (Welker Seamount, Gulf of Alaska), 795 m, 8 August 2004, 1 colony, USNM 1075367; *Alvin* 4035-8, 55°03′59″N, 140°24′28″W (Welker Seamount, Gulf of Alaska), 1119 m, 11 August 2004, 1 colony, USNM 1075376; *Alvin* 4039-17, 56°10′09″N, 142°42′02″W (Pratt Seamount, Gulf of Alaska), 960 m, 15 August 2004, 1 dry colony, USNM 1075377; *Alvin* 4039-24, 56°10′09″N, 142°42′02″W (Pratt Seamount, Gulf of Alaska), 914 m, 15 August 2004, 2 colonies, USNM 1075378; *Alvin* 4042-4, 56°22′42″N, 146°21′57″W (Giacomini Seamount, Gulf of Alaska), 1689–1937 m, 18 August 2004, USNM 1075396 and 1075394.

**Types and type locality.**— The original description is inadequate and unillustrated, and the holotype, which should be deposited at the MCZ, was not present in 2006. Nor is the type deposited at the YPM (Lazo-Wasem, pers. comm), ZMA, BM, or USNM, and thus is assumed to be lost. The specimen reported from *Gilliss*-21 is topotypic, collected only several km from the type locality, but is not sufficiently well preserved to be deemed a neotype. Type Locality: *Albatross*-3384: 7°31′30″N, 79°14′W (Gulf of Panama), 837 m.

**Description.**— The holotype was stated to be 17.5 cm in height, whereas the largest specimen reported herein is 33 cm in height and 16 cm in width, with a basal branch diameter of 4.5 mm (USNM 1075364). All colonies but one (T833-R56) are uniplanar, the odd specimen being a small, three-dimensionally branching bush. The axis is dark bronze in color, easily seen beneath a single layer of white, translucent coenenchymal scales. Branching is dichotomous and somewhat irregular, occurring every 9–11 mm, the axils forming an angle of about 30°; terminal branches are straight and rarely more than 3 cm in length. Calyces occur in approximately equal numbers as singles, pairs, and whorls of 3; calyces are spaced about 1.0–1.5 mm apart on the branch and are usually directed toward the base, often pointing downward at a 45° angle; calyces usually tend to favor one side of the flabellum. Calyces are 2.5–3.3 mm in height and flared apically.

Each calyx bears a distinctive arrangement of body wall sclerites. The 8 marginals are asymmetric in shape and size, the 5 on the abaxial and lateral edges each bearing a tall and narrow apical flute (Figs. 4A, 5B), whereas the 3 on the adaxial edge are not fluted, being much smaller and having rounded distal edges (Figs. 4C, 5C). The abaxial marginals are up to 1 mm in height and 1 mm in width, their basal edge bearing stubby digitate processes. Each adaxial marginal bears a well-developed, elongate, hollow flute, which may be up to 0.4 mm in length and 0.23–0.32 mm in width, its length being about 38–46% the length of the sclerite. The fluted part is relatively narrow and may be almost a closed cylinder (tubular) (Fig. 5B). The body wall scales below the marginals are arranged in 5 longitudinal rows. There are no body wall scales below the sagittal abaxial marginal, but on either side of this marginal there is a longitudinal row of 2 or 3 broad (0.8 mm) scales, each of which also bears apical flutes (Fig 4A). The marginals to either side of these two rows do not have aligned scales, but the 3 marginals on the adaxial side (Fig. 5C) each precede a row of 2 or 3 small (0.3–0.4 mm wide), non-fluted scales (Figs. 4C, 5D), such that the adaxial side of the polyp is completely covered with scales.

The opercular scales are triangular in shape, with a deeply creased outer surface that corresponds to a prominently keeled inner surface (Fig. 5A). Opercular scales range from 0.9–1.3 mm in length and have a L:W ratio of about 1.9. They have a straight proximal edge and sometimes a bifid apical end. The operculum is well developed and easily visible in lateral view.

The coenenchymal scales occur in one thin layer, often exposing the underlying branch axis. They are elongate (up to 0.6 mm) but irregular in shape, flat to slightly concave above, and have a uniformly granular outer surface, the rounded granules 10–13 µm in diameter (Fig. 5E). Only

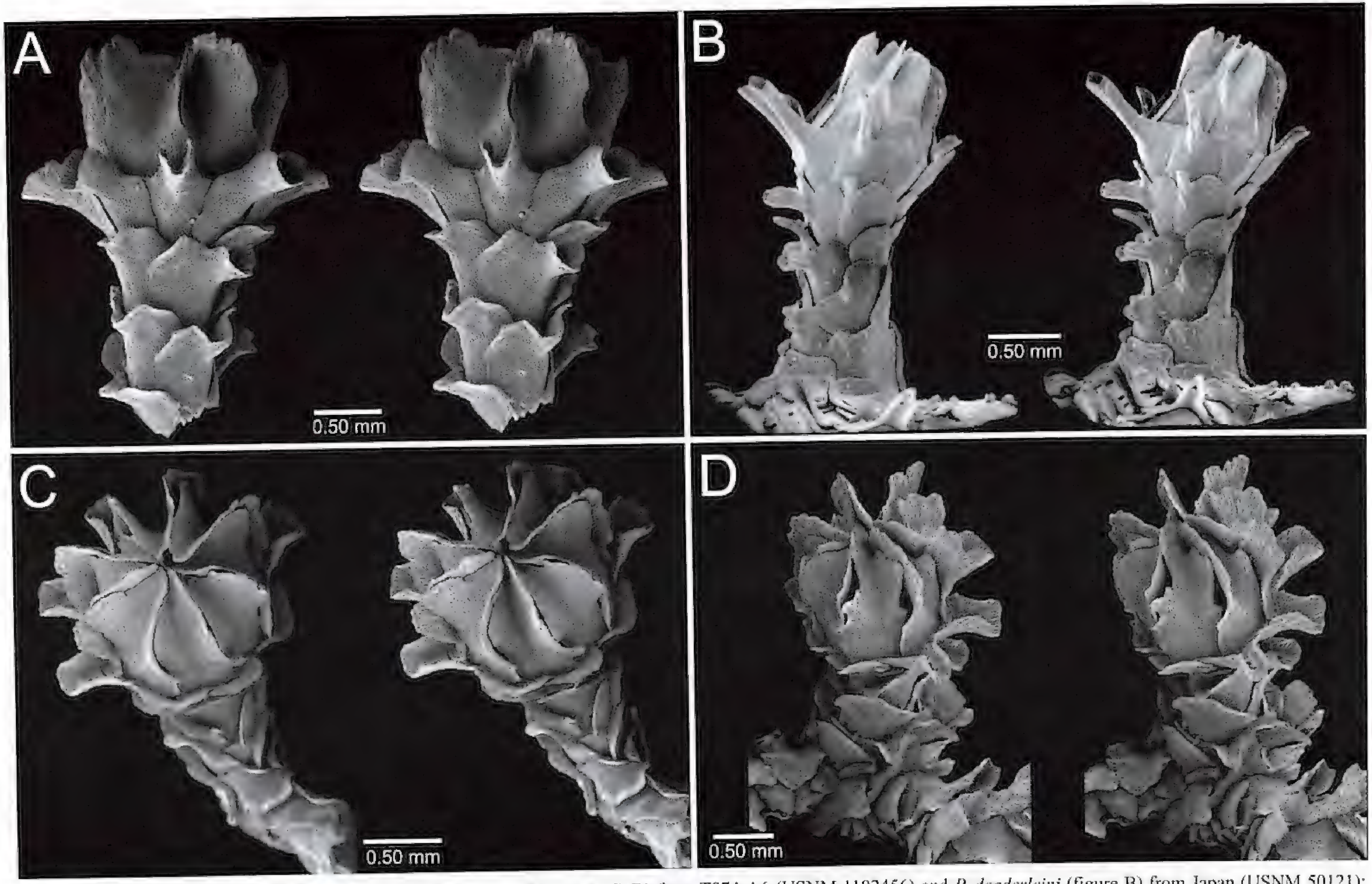

FIGURE 4. Stereo views of calyces of *Parastenella ramosa* (figures A, C–D) from T874-A6 (USNM 1102456) and *P. doederleini* (figure B) from Japan (USNM 50121): A. Abaxial view of a calyx. B. Lateral view of a calyx. C. Adaxail and opercular views. D. Oblique view of a calyx. All scale bars 0.5 mm.

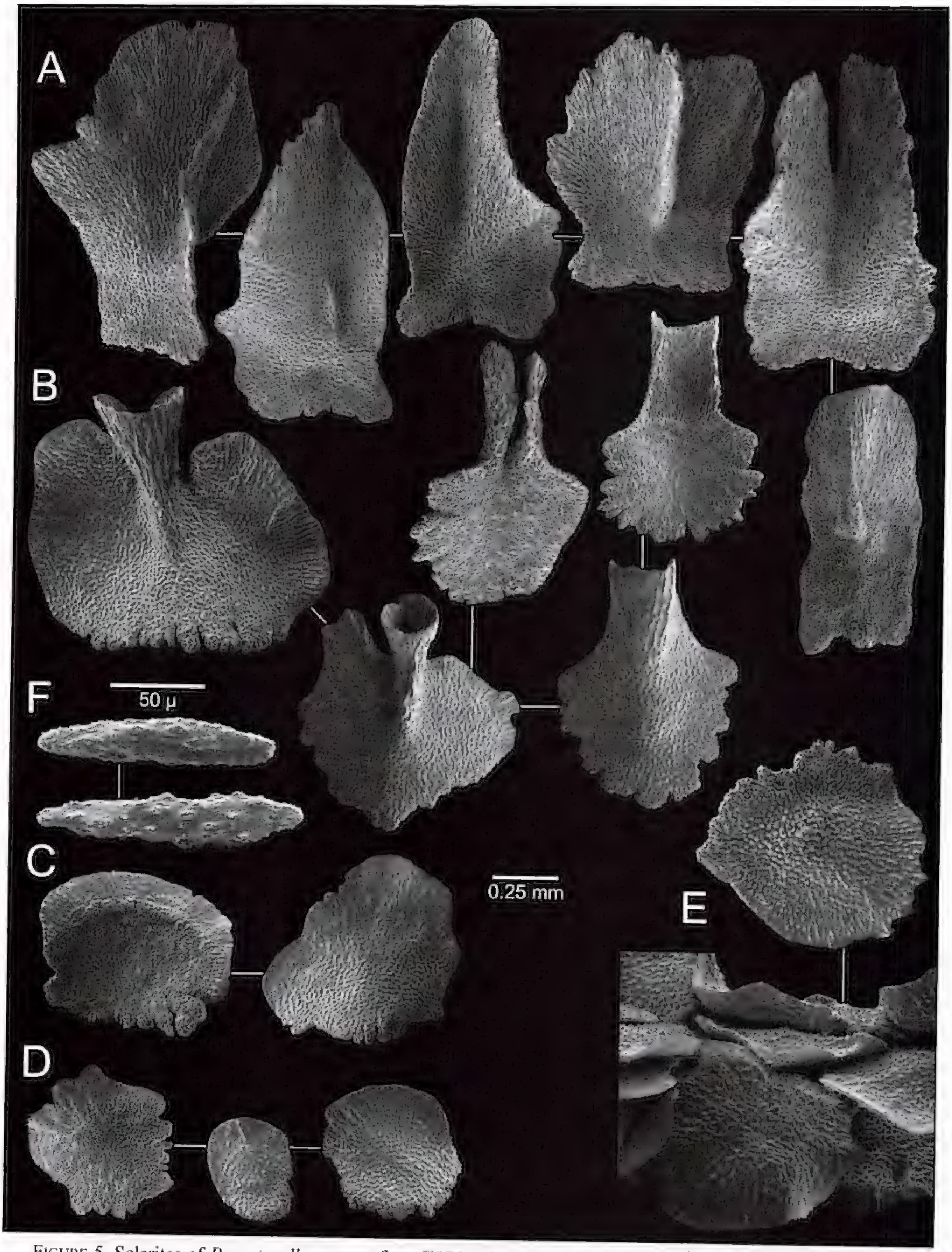

FIGURE 5. Sclerites of *Parastenella ramosa* from T874-A6 (USNM 1102456): A, Six opercular scales. B. Five marginal scales showing the distal flute. C. Two non-fluted abaxial marginal scales. D. Three adaxial body wall scales. E. Coenenchymal scales. F. Two pinnular rods. Scale bar for A–E, 0.25 mm; for F, 50 µm.

rarely will a coenenchymal scale bear a short vertical ridge. Pinnular sclerites are common, shaped as small rods 0.13–0.14 mm in length and about 13 µm in diameter (L:D = 10–11); their outer surface appears to be of a coarse crystalline texture (Fig. 5F).

**Comparisons.**— *Parastenella ramosa* is most similar to the type species of the genus, *P. doederleini* (Wright and Studer, 1889), originally described from off Sagami Bay, Japan at 3427 m (Table 2). Although the type of *S. doederleini* is no longer present at the BM, a small fragment of the type was borrowed from the ZMA (ZMAPOR3085), and for additional comparison a specimen was studied from Sagami Bay at 732 m (USNM 50121, Fig. 4B), as well as the re-description of the species by Versluys (1906) from specimens from Indonesia (1224 m). The two species have the same distinctive arrangement of body wall and marginal sclerites (i.e., 5 rows, with reduced adaxial marginal flutes [see Versluys, 1906: text-fig. 50]) and only two abaxial rows of fluted body wall scales. *P. doederleini*, however, differs in having more elongate (up to 53% of the length of the marginal) and more slender (only 0.08–0.10 mm wide) marginal flutes, more delicate calyces (only 2.2 mm tall, with a shaft diameter of 0.5 mm and a distal diameter of about 1.5 mm), and having one or more small (up to 0.08 mm), rounded knobs at the center and/or perimeter of the coenenchymal scales (see Versluys 1906: text-fig. 53–54). Given the similarity of the species, it is likely that Studer's (1894) identification of *S. doederleini* from off Panama at 1429 m (specimen missing from MCZ), taken quite close to the type locality of *P. ramosa*, is probably also *P. ramosa*.

**Distribution.**— Gulf of Panama, Rodriguez Seamount, Davidson Seamount, Monterey Bay, Axial 1998 South Flow, off British Columbia, Gulf of Alaska (Giacomini, Welker, Dickens, and Welker Seamounts); 665–1750 m.

### *Parastenella gymnogaster* Cairns, sp. nov.

Figures 1B, 6, 7.

**Material examined.**— Types.

**Types and type locality.**— Holotype: *Alvin* 4033-23, 54°59′1″N, 140°23′59″W (Welker Seamount off British Columbia), 2634 m, 9 August 2004, 1 colony now in many pieces (dry) and SEM stubs 1281–1285, USNM 1075464 and 1 piece, CAS 175306. Paratypes: *Alvin* 1428, 44°40′N, 125°18′W (Juan de Fuca Ridge, Oregon), 2050 m, 9 August 1984, 1 complete colony, USNM 74691; T1007-A8, 45.327°N, 130.385°W (Vance F Seamount off Oregon), 2064 m, 29 July 2006, 1.90°C, several branches in alcohol, USNM 1102457; T1012-A17, 45.623° N, 130.664° W (Vance B Seamount off Oregon), 1962 m, 3 August 2006, 1.91°C, 1 branch, USNM 1102458; JD-093(30), 52°59′01″N, 161°14′57″W (Derickson Seamount, Gulf of Alaska), 2773 m, 20 Jul 2004, colony in alcohol, USNM 1081171.

**Description.**— The holotype colony is fragmented into many pieces, the largest 28 cm in height, having a basal branch diameter of 6.5 mm. All colonies are strictly uniplanar. The axis is bronze in color and faintly longitudinally striate. Branching is dichotomous and somewhat irregular, occurring every 12–15 mm; terminal branches rarely exceed 4 cm in length. Calyces occur as singles, pairs, and in whorls of 3; calyces are closely spaced on the branch, only about 0.4–0.6 mm apart. The calyces are curved strongly toward the base such that the distal end of each calyx almost touches the branch. Calyces are 2.2–3.0 mm in height and flared apically.

Each calyx bears a distinctive arrangement of body wall scales. Like *P. ramosa*, the 8 marginals are asymmetric in shape and size (Fig 6C), the 5 on the abaxial and lateral edges (Figs. 6A, 7B) bearing a short apical flute, whereas the 3 on the adaxial edge (Figs. 6B, 7C) being much smaller and not fluted, having rounded distal edges. The abaxial marginals are wider than tall, about 0.9 mm wide and 0.75 mm tall, each bearing a short, broad (U-shaped, not tubular) marginal flute, which is up to 0.25 mm in length and 0.25–0.35 mm in width, the length of the flute being only about 20–25% the length of the marginal. The body wall scales below the marginals are arranged

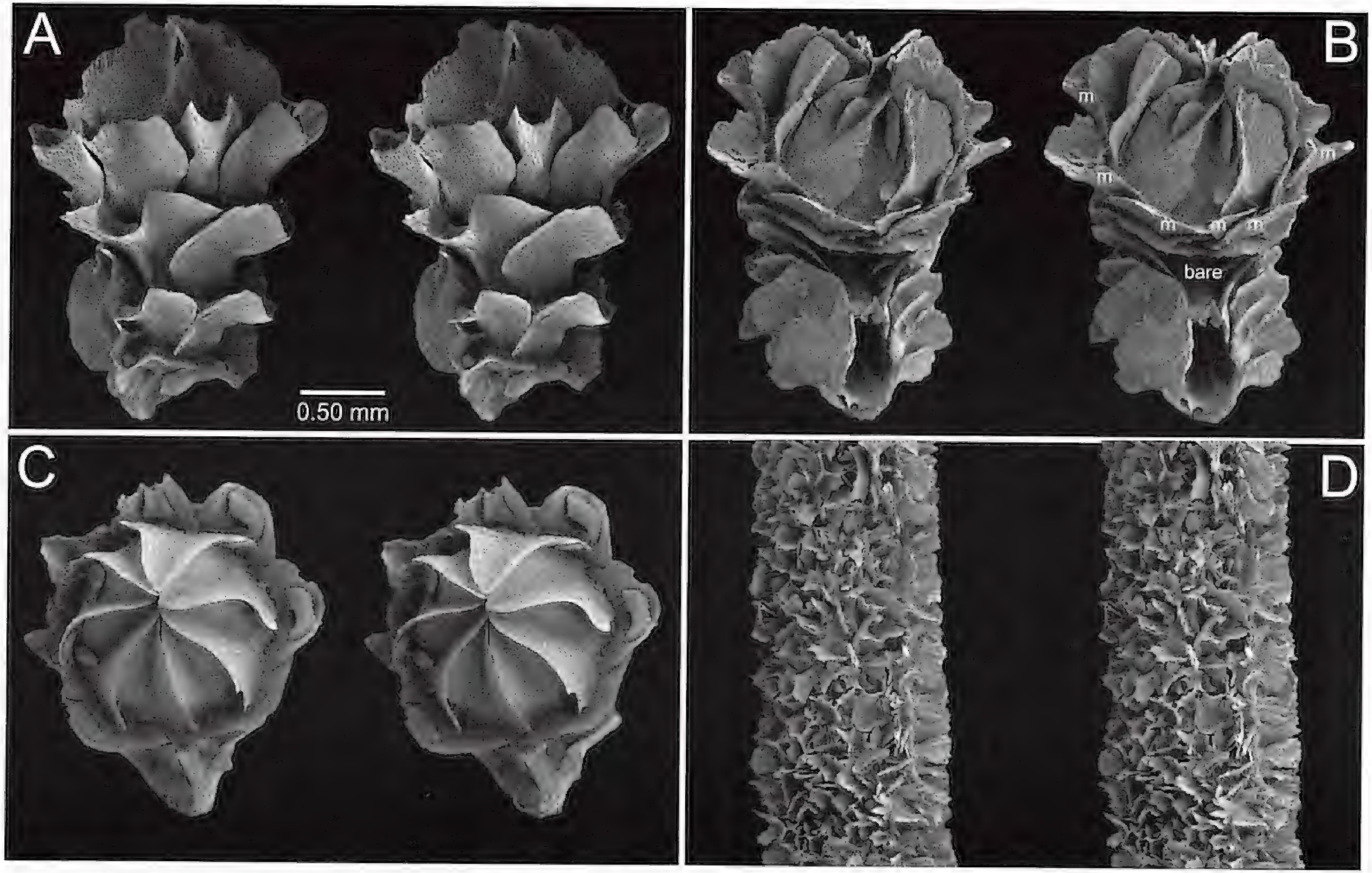

FIGURE 6. Stereo views of the holotype of *Parastenella gymnogaster*: A. Abaxial side of a calyx showing fluted body wall scales. B. Adaxial side of a polyp showing bare midline and six of the eight marginal scales, each labeled as m. C. Opercular view showing offset of marginals and opercular scales. D. Coenenchymal scales with ornate ridging. Scale bar for all figures 0.5 mm.

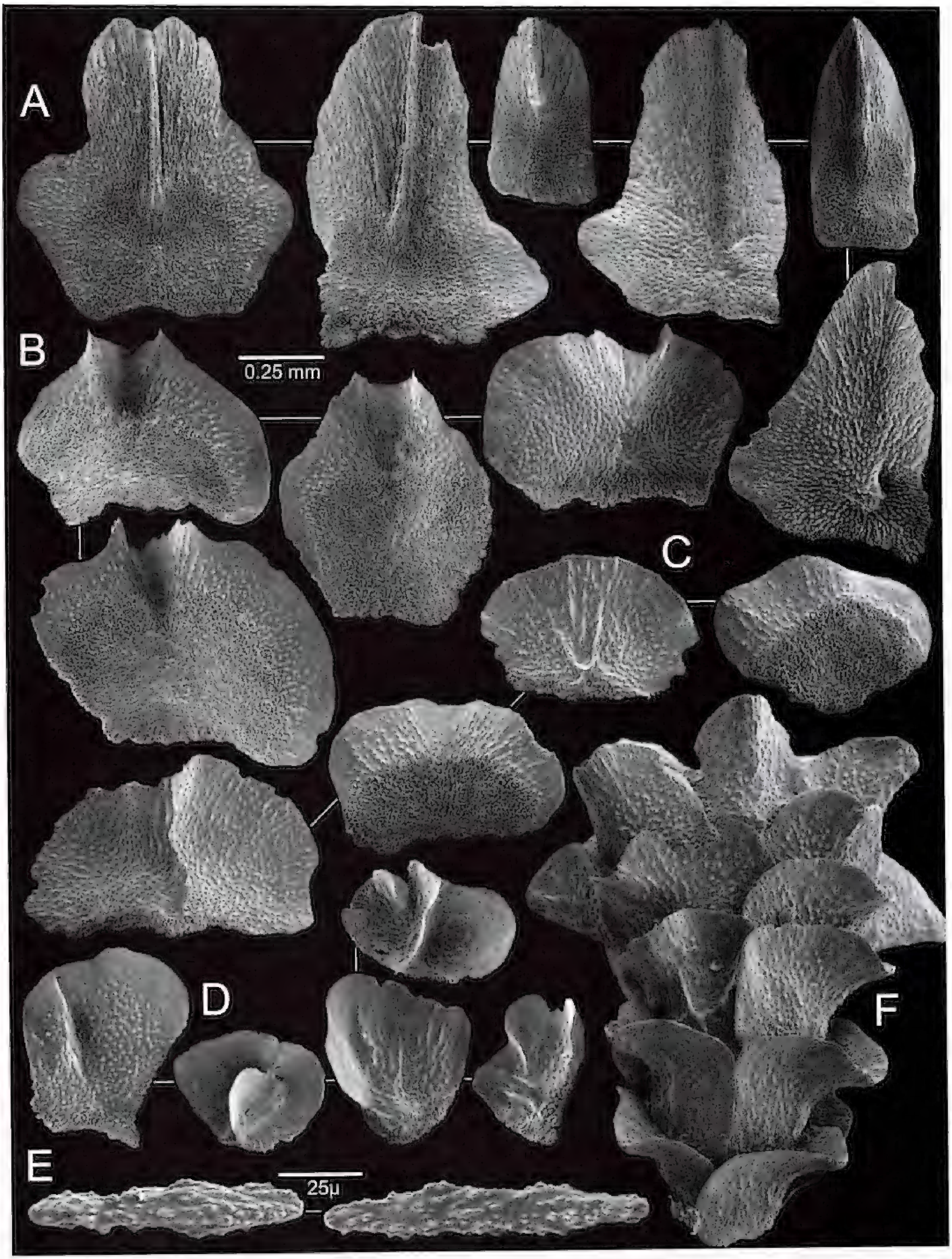

FIGURE 7. Sclerites from holotype of *Parastenella gymnogaster*: A. Six opercular scales. B. Four marginal scales showing short, broad flutes. C. Four abaxial body wall scales. D. Five coenenchymal scales showing ridges on outer surface. E. Two pinnular rods. F. Abaxial view of a juvenile calyx showing closely-spaced, imbricate, aligned abaxial scales. Scale bar for A–D, F, 0.25 mm; E, 25 µm.

in 6 longitudinal rows. There are no body wall scales below the sagittal abaxial marginal, but on either side of this marginal there is a longitudinal row of 4–6 broad (up to 0.9 mm wide and 0.5 mm tall) scales, each of which also bears short apical flutes (Fig. 7F). These body wall scales are closely spaced, as though stacked, their flutes in direct alignment, their width covering the entire abaxial side as well as part of the lateral edge of the calyx. Toward the base of the calyx they often bear a low longitudinal ridge on their outer surface (Fig. 7D). On each of the adaxial lateral sides of the calyx is a short row of 2–3 small (0.7 mm tall, 0.45 mm wide), non-fluted scales. On the adaxial side of the calyx, each non-fluted marginal is bordered by only one additional body wall scale, which produces a small bare region of the lower adaxial side of the calyx (Fig. 6B).

The opercular scales are triangular in shape, with a deeply creased outer surface that corresponds to a prominently keeled inner surface (Figs. 6C, 7A). The ab- and adaxial operculars are symmetrical, the former with 2 lateral shoulders, the latter with no shoulders; the lateral operculars are asymmetric, each having only one lateral shoulder on the lower adaxial margin. The abaxial operculars are 1.0–1.1 mm in length, having a L:W of 1.0–1.1; the laterals are 0.9–1.0 mm in length, with a L:W of about 1.4; and the small adaxials are only 0.6–0.7 mm in length, with a L:W of 1.7–2.3.

The coenenchymal scales are elliptical to irregular in shape (up to 0.6 mm wide) and have a highly concave upper surface, each bearing one or more tall (up to 0.6 mm) ridges, the ridges sometime taller than the width of the scale. The ridging may sometimes be quite ornate (Figs. 6D, 7D) and complex. Pinnular sclerites are common, shaped as small rods up to 97 µm in length and 12–16 µm in diameter (L:D = 6–8), their outer surfaces bearing small granules (Fig. 7E).

COMPARISONS.— *Parastenella gymnogaster* is one of three species having lesser developed adaxial marginal and submarginal body wall scales (Table 2), but is unique in having such a highly curved calyx that results in a naked lower adaxial region. It is also unique in having six rows of body wall scales, the scales of the two abaxial rows being quite broad, crowded, and linearly arranged. Although it overlaps in distribution with *P. ramosa* and even occurs on some of the same seamounts, it is usually found deeper than *P. ramosa*.

ETYMOLOGY.— The name *gymnogaster* (Greek, *gymno* = bare + *gaster* = stomach or belly) refers to the naked adaxial region of the body wall that is not covered with scales.

DISTRIBUTION.— Juan de Fuca Ridge off Oregon and eastern Pacific seamounts from off Oregon (Vance Seamount) to the Gulf of Alaska south of the eastern Aleutian Islands (Derickson Seamount, Gulf of Alaska); 1962–2773 m.

### ***Parastenella pacifica* Cairns, sp. nov.**

Figures 1C, 8, 9.

MATERIAL EXAMINED.— Types.

TYPES AND TYPE LOCALITY.— HOLOTYPE: 45°25′N, 125°11′W (west of Cape Meares, Oregon), 1498–1527 m, date unknown, 1 dry colony broken into many fragments and SEM stubs 1286–1290, USNM 1071799. PARATYPES: *WE Ricker* tow 35 (#256), 52°59′41″N, 133°05′06″W (off Queen Charlotte Islands, British Columbia), 1986–2105 m, 8 September 2004, 1 dry colony, USNM 1094060, and one fragment, CAS 175307; *WE Ricker* tow 40 (#300), 54°06′05″N, 134°04′35″W (off Queen Charlotte Islands, British Columbia), 1915–2014 m, 10 September 2004, 1 branch in alcohol, USNM 1094070.

DESCRIPTION.— The largest piece of the holotype is 30 cm in height and 15 cm broad, but the dry colony is now fragmented into over a dozen pieces and several hundred unattached calyces. Nonetheless, it is clear that colonies are uniplanar and flabellate, the holotype having a basal branch diameter of 8.8 x 6.5 mm, the greater diameter oriented perpendicular to the flabellum. The axis is bronze to light brown in color. Branching is dichotomous and somewhat irregular, occurring at intervals of 10–15 mm; terminal branches are relatively short, rarely more than 10 m in length. Calyces occur in approximately equal numbers as singles, pairs, and whorls of 3; calyces are spaced 0.5–1.5 mm apart and are usually oriented perpendicular to the axis; calyces tend to favor one side of the flabellum. Calyces are 2.1–3.0 mm in height and flared apically, having a slender shaft of about 0.85 mm diameter that broadens to a flared apical end 1.7–2.0 mm in diameter.

The 8 fluted marginal scales are all of the same shape and size, producing a symmetrical rosette when viewed from above (Fig. 8C). The marginals are up to 0.8 mm in length and 0.5–0.7 mm in basal width, each bearing a broad and shallow apical flute that constitutes 30–40% the length of the scale (Fig. 9B). The marginal flutes are about 0.30–0.45 mm in length and 0.35–0.40 mm wide, their inner surface covered with small apically directly spines (Fig. 9C). The submarginal body wall scales are roughly arranged in 8 longitudinal rows, each row having 3 or 4 scales that intercalate with those from the adjacent rows (Fig. 8A); however, the alignment is obscured near the calyx base. The polyp is completely covered with body wall scales, there being no naked adaxial region (Fig. 8B). The submarginals are 0.7–0.9 mm in width and length, each having a rounded distal edge; none of them bear flutes (Figs. 8A, 9D). Those near the base of the calyx often bear 1–3 low, longitudinal ridges.

The opercular scales are triangular in shape, with a deeply creased outer surface and longitudinally keeled inner surface (Fig. 9A). There is little difference in the size of the operculars, the symmetrical abaxials being 0.9–1.05 mm in length (H:W = 1.4–1.5), the asymmetric laterals 1.0–1.06 mm in length (H:W = 1.7–2.0), and the symmetric adaxials up to 0.9 mm in length (H:W = 2.2–2.3). The abaxials sometimes have notches on their lateral edges that appear to articulate with a notch on the adjacent lateral, appearing to allow a more efficient closing of the operculum.

The coenenchymal scales form one thin layer over the axis (Fig. 8D) and are elliptical to somewhat irregular in shape, but rarely more than 0.6 mm in width. All coenenchymals have a highly concave outer surface with upturned edges, resembling closely placed water lilies on a pond. Most coenenchymal scales bear at least one if not several tall (up to 0.15 mm) straight ridges on their outer surface, sometimes arranged in a complex pattern (Fig. 9E). Pinnular sclerites are common, shaped as small rods 95–105 µm in length and about 17 µm in diameter, thus having a L:D of about 6; their surface is granular (Fig. 9F).

**COMPARISONS.**— *Parastenella pacifica* is one of three species having equally developed marginal and submarginal scales (Table 2), and is most similar to *P. atlantica*, the latter known only from the North Atlantic. It differs from that species in having prominently ridged coenenchymal scales, longitudinally ridged body wall scales, and in having numerous pinnular rods of a larger size.

**ETYMOLOGY.**— Named *pacifica* for its close similarity to *P. atlantica*, perhaps being a geminate pair, but having a range in a different ocean.

**DISTRIBUTION.**— Continental slope off Oregon to British Columbia (Queen Charlotte Islands), 1527–1986 m.

### *Calyptrophora* Gray, 1866

**TYPE SPECIES.**— *Calyptrophora japonica* Gray, 1866, by monotypy.

**DIAGNOSIS.**— Colonies uniplanar or flagelliform. Calyces arranged in whorls, in most species the calyces facing upward. Calyces composed of two annular sclerite rings, each composed of two inseparably fused scales; a pair of crescent-shaped infrabasals is usually present. Distal margin of body wall scales often spinose. Operculum composed of 8 triangular scales each usually having a longitudinal keel on inner surface. Coenenchymal scales elongate and flat.

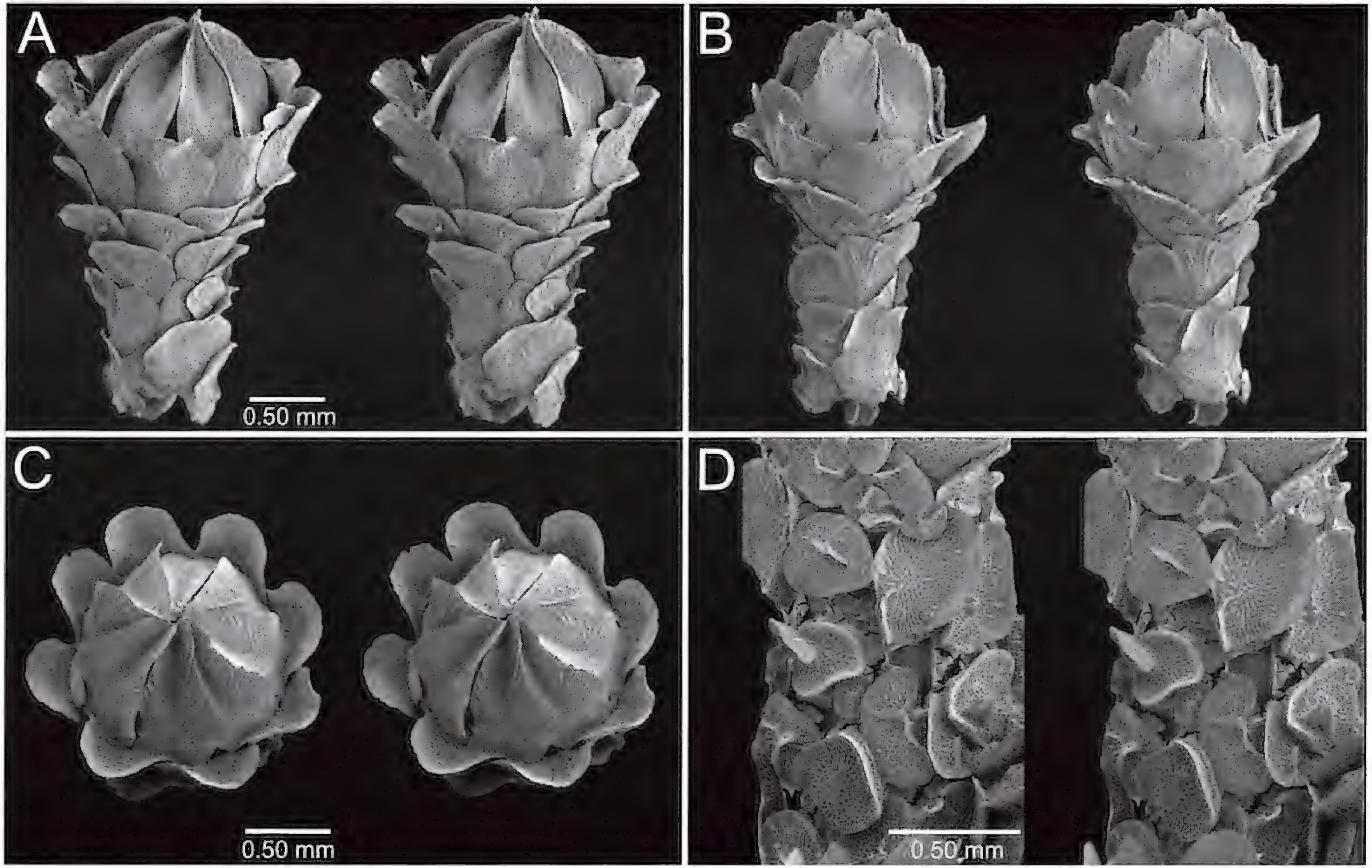

FIGURE 8. Stereo views of the holotype of *Parastenella pacifica:* A. Abaxial view of a calyx. B. Adaxial view of a calyx. C. Opercular view. D. Ridged coenenchymal scales. Scale bar for A-B, 0.5 mm; C, 0.5 mm; D, 0.5 mm.

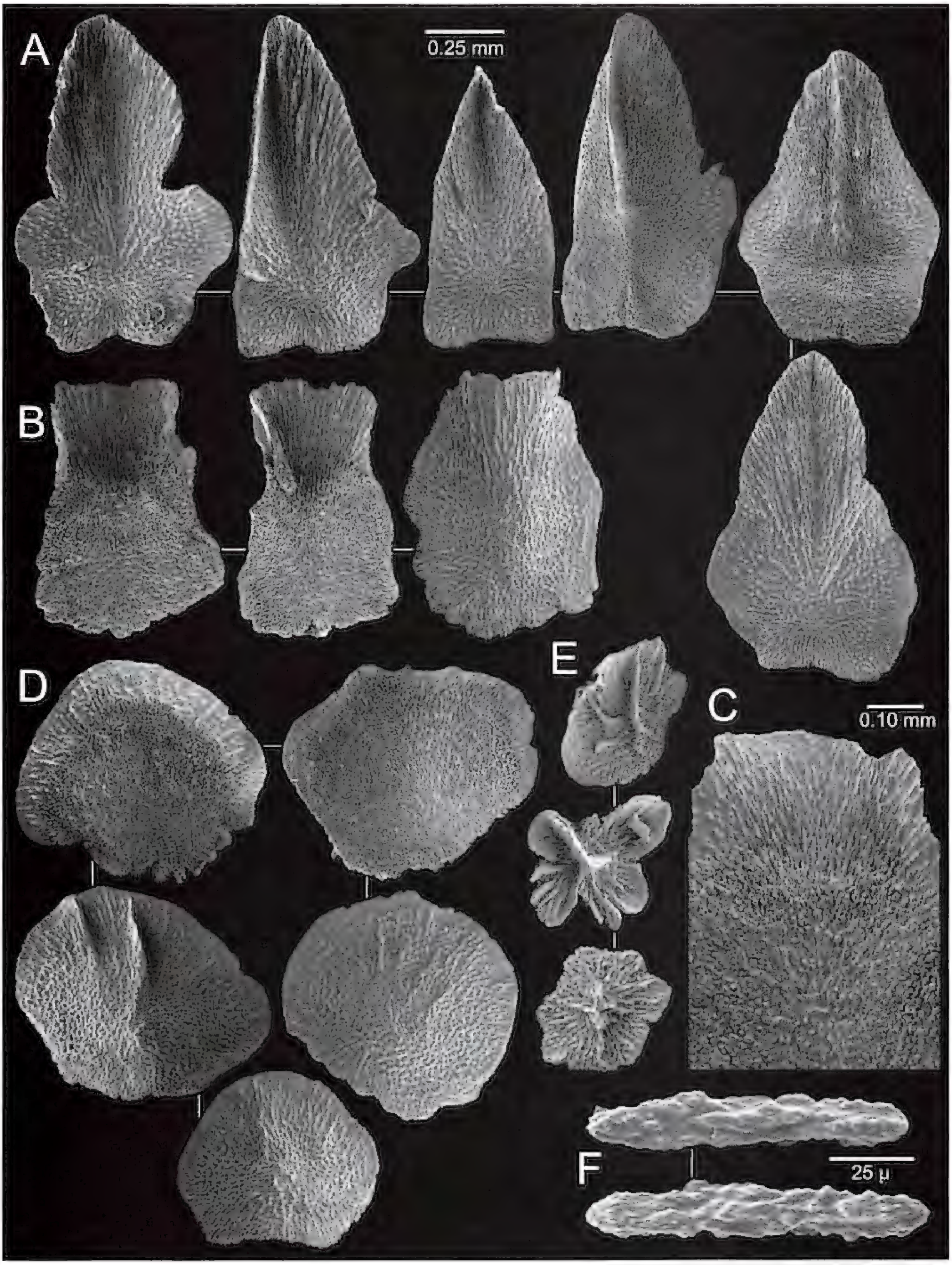

FIGURE 9. Sclerites from holotype of *Parastenella pacifica*: A. Six opercular scales. B. Three marginal scales. C. Spinose and tuberculate inner face of a marginal scale. D. Five abaxial body wall scales. E. Three ridged coenenchymal scales. F. Two pinnular rods. Scale bar for A-B, D-E, 0.25 mm; C, 0.10 mm; F, 25 µm.

**Remarks.**— Species of this genus have been discussed by Bayer (2001) and Cairns (2007).

**Distribution.**— Indian, Pacific, and Atlantic Oceans; 229–3701 m.

### *Calyptrophora* sp. cf. *C. antilla* Bayer, 2001

Figures 1F, 10, 11.

?*Calyptrophora japonica* form B.– Versluys, 1906:116–118 (in part: specimen 3, figs. 166–168).
?*Calyptrophora antilla* Bayer, 2001:374–375, fig. 4.

**Material examined.**— T943-A3, 35.739°N, 122.718°W (Davidson Seamount, California), 1683 m, 28 January 2006, 2.54°C, several branches and SEM stubs 1291–1294, 1306–1307, USNM 1102459, and 1 branch, CAS 175308; T943-A6, 35.735°N, 122.719°W (Davidson Seamount, California), 1763 m, 28 January 2006, 2.37°C, several branches, USNM 1102460.

**Types and type locality.**— The syntypes of *C. antilla* are deposited at the USNM (52914). Type Locality: 20°09′N, 73°29′W (Windward Passage between Cuba and Haiti), 1399 m.

**Description.**— The largest branch fragment is only 11 cm in length and 2.1 mm in basal branch diameter, but *in situ* photographs taken prior to collection indicate a dichotomously branched, flabellate colony approximately 20 cm in height and width; branch axils 20–25°. The axis is woody in texture and yellow in color; the calyces are white. Calyces are arranged in whorls of 3–5 (Fig. 10A), the larger number corresponding to larger-diameter branches; the calyces face upward. There are 11–13 whorls per 3 cm branch length, the whorls somewhat closely spaced at 0.8–1.0 mm intervals on the branch; the whorl diameter is about 3.6 mm. Calyces are 1.8–2.2 mm in horizontal length.

Each calyx is encased in two pairs of fused, ring-like scales (i.e., the basals and buccals), each pair meeting in a narrow adaxial symphysis (Fig. 10D). The basal scales are 0.8–0.9 mm in height (exclusive of the spines) and have rounded dorsolateral edges. Each basal bears an elongate pointed spine on its anterolateral edge (Fig. 11B). The basal spines are 0.9–1.0 mm in length, 0.16–0.19 mm in basal diameter, round in cross section, and bear finely serrate longitudinal ridges (Fig. 11F); the spines are curved slightly forward. The horizontally oriented buccal scales (Figs. 10D, 11D) are slightly longer, 0.9–1.2 mm in length, and have a rounded dorsolateral edge. Each buccal bears two spines on its distal margin, one spine aligned with each of the abaxial and outer-lateral opercular scales (Fig. 10C). These spines are similar to the basal spines in shape (cylindrical, ridged, serrate) but are smaller, being only 0.5–0.7 mm in length and 0.10–0.13 mm in basal diameter. Two discrete, crescent-shaped infrabasal scales (Fig. 11C), 0.35–0.45 mm in height, form a sleeve into which the calyx articulates with the coenenchymal scales.

The opercular scales (Figs 10C, 11A) are triangular in shape, with a fairly flat outer surface that is uniformly granular, the granules radiating from a point on the midline and near the base of the scale. Apically the outer surfaces of the operculars are slightly longitudinally creased, which corresponds to an elongate, rounded keel on the inner surface, the inner surface otherwise being tuberculate; the tips of the operculars are blunt. The two abaxials are symmetrical in shape, 1.0–1.16 mm in length, and have a L:W of 1.8–2.5. The four lateral operculars are slightly asymmetrical, each having a small shoulder on the basal adaxial edge; they are 0.8–1.0 mm in length, with a L:W of 1.6–1.9. The adaxial operculars are symmetrical, about 0.65 mm in length, and have a L:W of only 1.6. Tentacular sclerites are common, being 0.10–0.15 mm in length, 0.036–0.042 mm in width, and about 0.006 mm in thickness. They are straight or bent as much as 180° in the plane of their lesser axis (Fig. 11G).

The coenenchymal scales (Fig. 11E) are elongate (up to 1.3 mm in length), but often irregular in shape, with a flat, evenly granular outer surface and a tuberculate inner surface.

**Comparisons.**— Bayer (2001) divided the species of *Calyptrophora* into two species com-

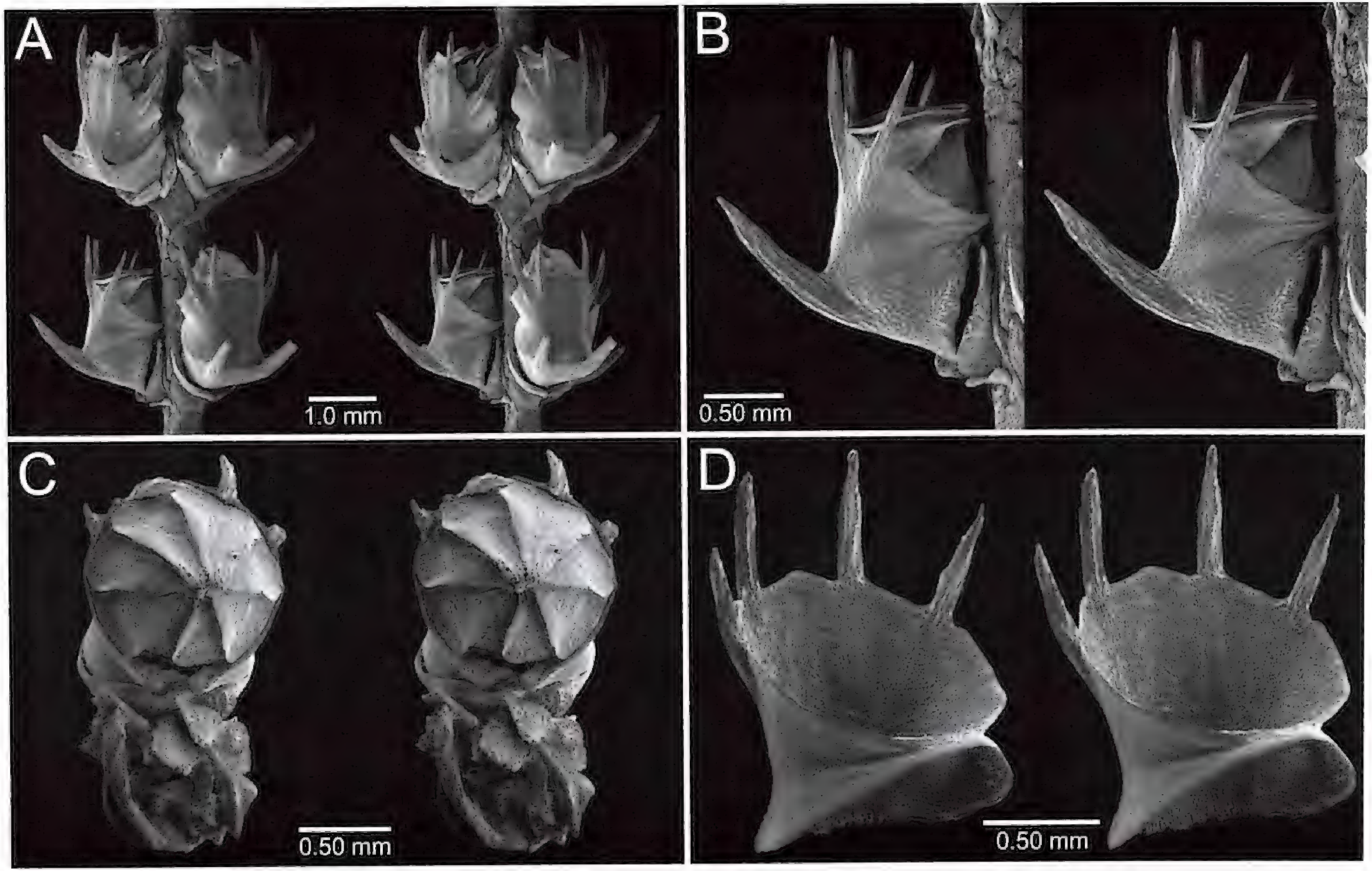

FIGURE 10. Stereo views of *Calyptrophora* sp. cf. *C. antilla* from T943-A3 (USNM 1102459): A. Two whorls of calyces. B. Lateral view of a calyx. C. Opercular view of a calyx. D. Inner view of a pair of fused buccal scales, showing ridged spines. Scale bar for A, 1 mm; B, 0.5 mm, C–D, 0.5 mm.

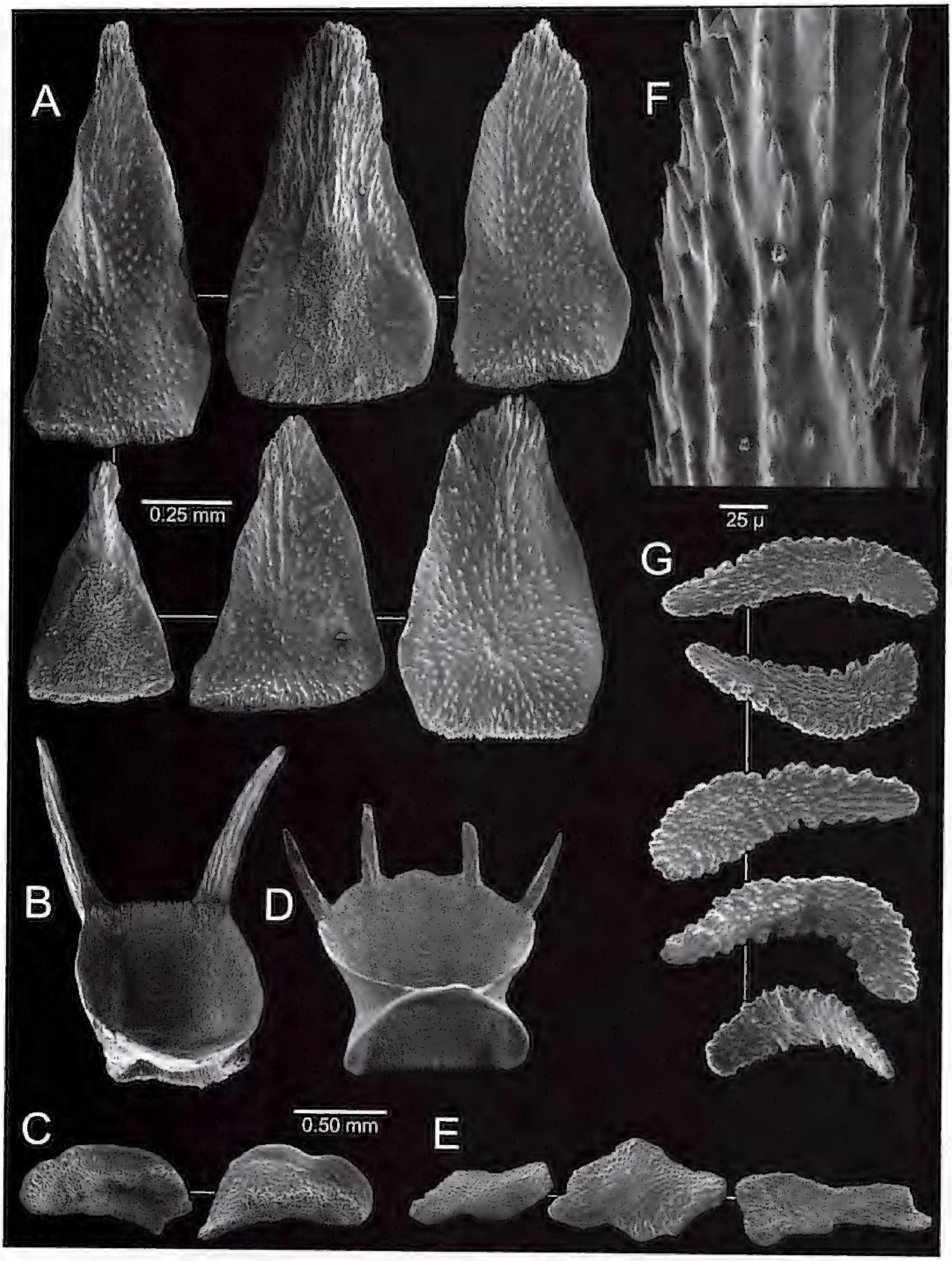

FIGURE 11. Sclerites of *Calyptrophora* sp. cf. *C. antilla* from T943-A3 (USNM 1102459): A. Six opercular scales. B. Adaxial view of a pair of fused basal scales. C. Two infrabasal scales. D. Adaxial view of a pair of fused buccal scales. E. Three coenenchymal scales. F. Enlargement of basal spine showing serrate ridges. G. Five curved pinnular scales. Scale bar for A, 0.25 mm; B–E, 0.5 mm; F–G, 25 μm.

plexes, the *japonica*-complex, having polyps that are directed upward, and the *wyvillei*-complex, having polyps directed downward. The *japonica*-complex was further divided into two species groups, the first having marginal spines on the buccal scales, the second lacking buccal marginal spines. This species clearly falls into the first species group of the *japonica*-complex, which contains seven of the 12 species: four occurring in the western Pacific and three in the western Atlantic. It has been compared to the types of seven of these eight species and topotypic specimens of *C. japonica*, and surprisingly, this taxon is most similar, if not the same, to the western Atlantic *C. antilla*, which has a known range of the Greater Antilles and the New England Seamounts at 1399–1692 m (Cairns 2007). It differs from *C. antilla* only in having slightly longer buccal spines (those of *C. antilla* are rarely more than 0.45 mm long), which is probably within the range of variation for the species.

This taxon is also quite similar, and may be the same, as *Calyptrophora japonica* form B (specimen 3) of Versluys (1906), a specimen collected from Indonesia at 1301 m. As Bayer (2001:372) suggested, this species is very similar to *C. clarki* Bayer, 1951, except that the latter has broader plate-like basal spines. Although not examined, Versluys' specimen appears to differ only in having longer basal spines (up to 1.0 mm). According to Bayer (2001:372), Versluys' variant forms are undescribed species different from *C. japonica*.

DISTRIBUTION.— Davidson Seamount, 1683–1763 m; ?Western Atlantic (Cairns 2007) and ?Indonesia (Versluys 1906), 1301–1692 m.

### *Calyptrophora bayeri* Cairns, sp. nov.

Figures 1H, 12, 13.

?*Calyptrophora japonica* form C (specimen 10).–Versluys, 1906:119–121, text-figs. 170–174.

MATERIAL EXAMINED.— Types.

TYPES AND TYPE LOCALITY.— HOLOTYPE: T943-A3', 35.739°N, 122.718°W (Davidson Seamount, California), 1683 m, 28 January 2006, 2.54°C, one branch and SEM stubs 1295–1297, 1302–1303, USNM 1102461, and 1 branch, CAS 175309.

DESCRIPTION.— The largest branch fragment is only 11 cm in length and 2.6 mm in basal branch diameter, clearly part of a larger colony that was loosely dichotomously branched and having branch axils of 40–50° divergence. The axis is woody in texture and a dark golden brown in color, easily seen through the thin, single layer of translucent coenenchymal scales. Calyces are white and arranged in whorls of 3 or 4 (usually 4); calyces face upward (Fig. 12A). There are 10–11 whorls per 3 cm branch length, the whorls spaced 1.0–1.2 mm apart; the whorl diameter is about 3.8–4.2 mm. Calyces are 2.2–2.7 mm in horizontal length.

The basal scales are 1.0–1.2 mm in height (exclusive of the spines) and have dorsolateral edges that met at a 90° angle, but not associated with an external ridge. Each basal scale bears a massive spine on its anterolateral edge (Fig. 13C). These spines are up to 1.0 mm in length and round in cross section only distally, for the most part being quite flattened, up to 0.5 mm wide at their base and only 0.1 mm in thickness. Their inner faces bear parallel rows as small granules and spines (Fig. 13F), whereas their outer surface bears low, rounded granules. The buccal scales are 1.8–2.2 mm in length and have rounded dorsolateral edges. They too bear flattened distal spines or teeth, each calyx having 4, 6 or 8 (usually 6) triangular protuberances, each of which is rarely over 0.2 mm in length (Figs. 13B, H). The infrabasal scales (Fig. 13D) are of the typical crescent shape and are up to 0.6 mm in height.

The opercular scales (Fig 13A) are triangular in shape, but with a somewhat blunted distal point. Apically the outer surface is longitudinally creased, which corresponds to a sharp keel on the

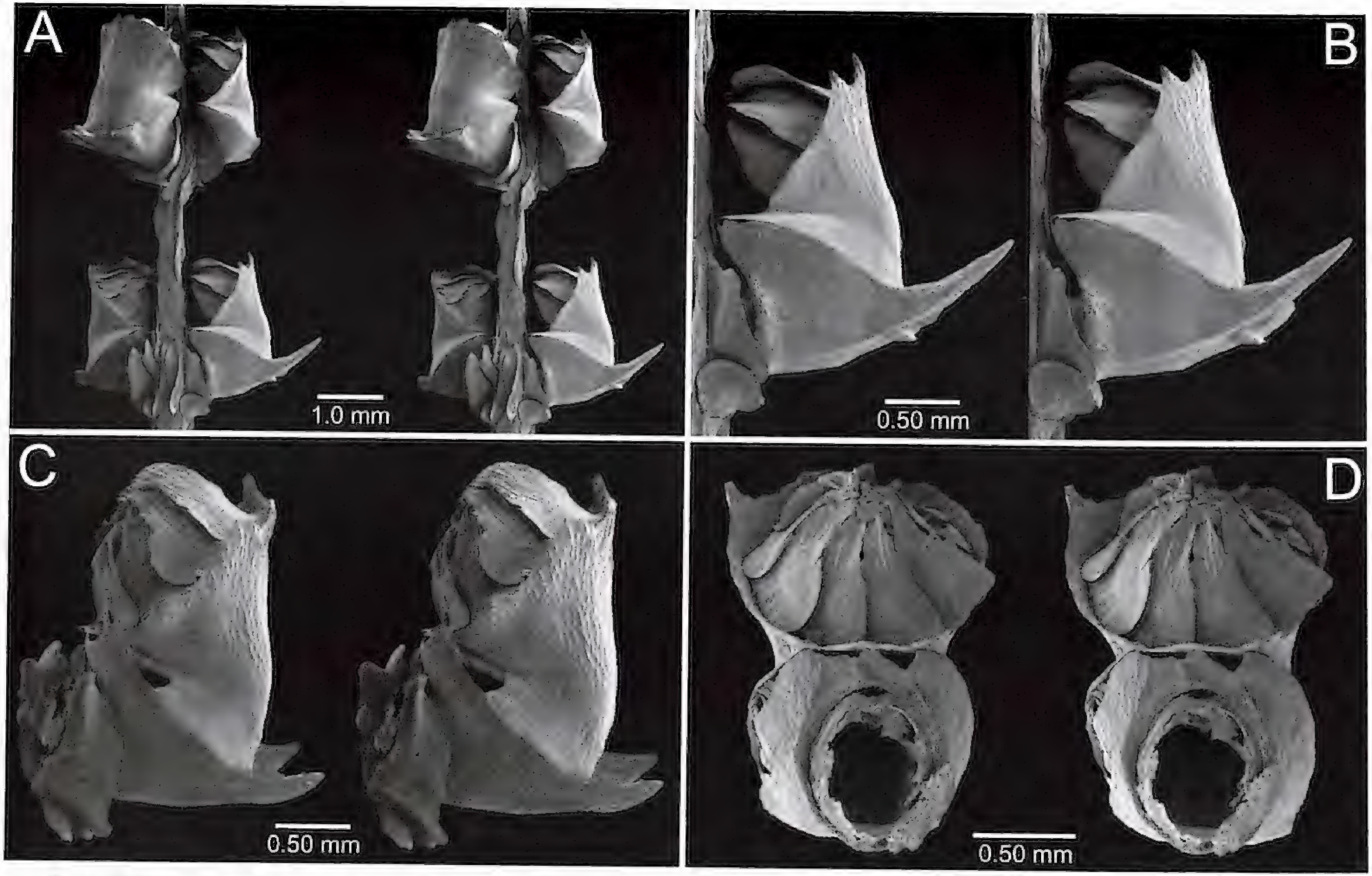

FIGURE 12. Stereo views of the holotype of *Calyptrophora bayeri:* A. Two whorls of calyces. B-C. Lateral views of calyces. D. Adaxial view of a calyx. Scale bar for A, 1 mm; B–D, 0.5 mm.

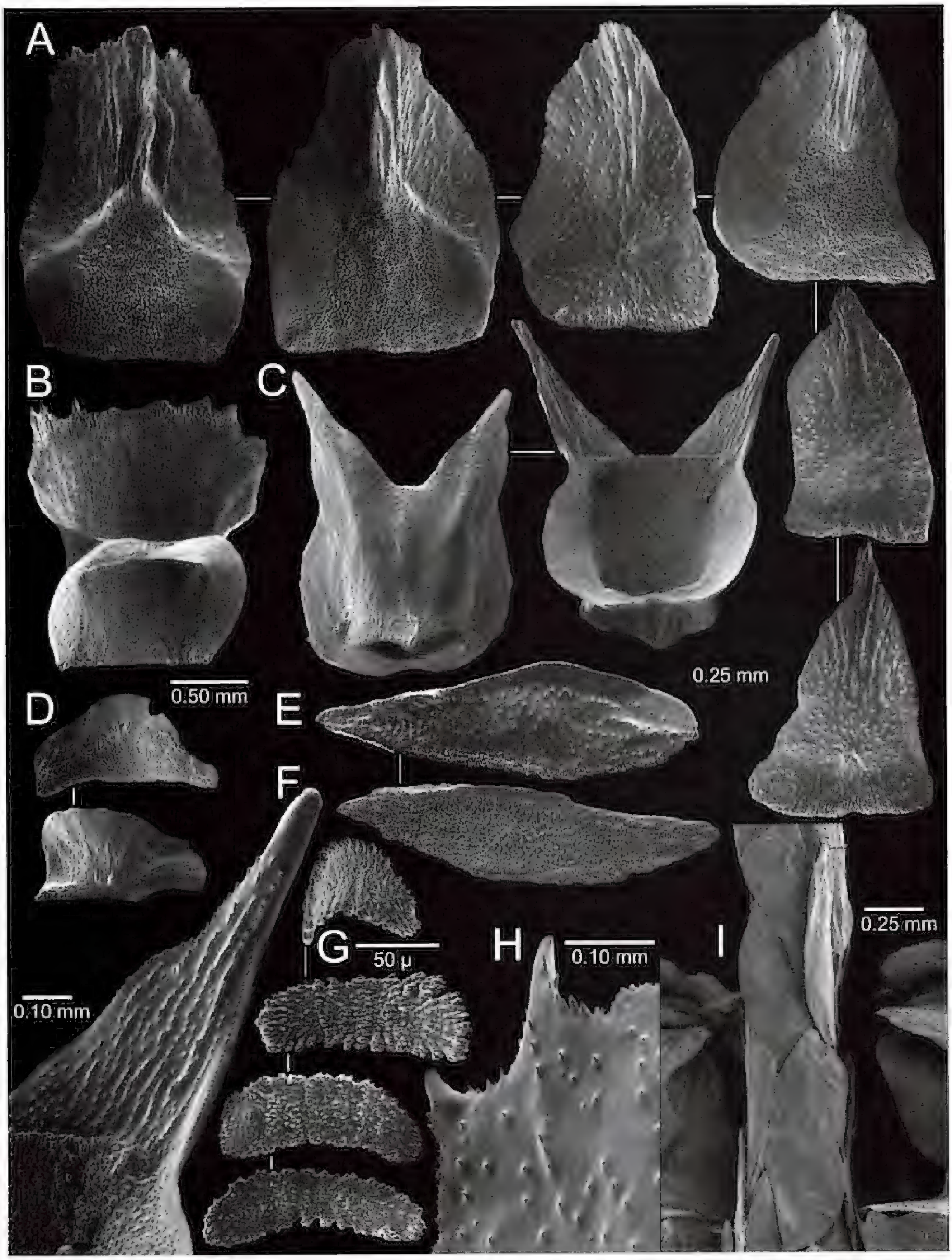

FIGURE 13. Sclerites from holotype of *Calyptrophora bayeri*: A. Five opercular scales. B. Adaxial view of a pair of fused buccal scales showing the dentate distal margin. C. Ab- and adaxial views of two pairs of fused basal scales. D. Two infrabasal scales. E. Two coenenchymal scales. F. Inner side of a basal scale spine showing parallel rows of spines. G. Four curves pinnular scales. H. Enlargement of buccal spines. I. Coenenchymal scales in place. Scale bar for A, E, 0.25 mm; B–D, 0.5 mm; F, 0.1 mm; G, 50 µm; H, 0.1 mm; I, 0.25 mm.

inner surface; the tuberculate region on the inner surface seems to be somewhat raised. The abaxial operculars are symmetrical in shape, 0.96–1.07 in length, and have a L:W of 1.4–1.55. The four lateral operculars are slightly asymmetrical, 0.79–0.91 mm in length, and have a similar L:W ratio. The adaxial operculars are 0.75–0.8 mm in length, symmetrical with a pointed tip, and have a L:W of about 1.5–1.7. Tentacular sclerites are common, measuring up to 0.15 mm in length, 0.056 mm in width, and about 0.007 mm in thickness (Fig. 13G). They are usually curved in the plane of their lesser axis.

The coenenchymal scales (Figs. 13E, I) are fusiform (L:W = 3–4), up to 1.15 mm in length, with a flat to slightly concave outer surface and tuberculate inner surface. Occasionally, a coenenchymal is attached on edge (Figs. 12A), these located between infrabasal scales of adjacent calyces.

**Comparisons.**— *Calyptrophora bayeri* was compared to type material of all species in the *japonica*-complex, except for *C. japonica*, for which topotypic specimens from Japan were examined (USNM 30027, 49323). Its flattened basal spines and short triangular buccal spines distinguish it from all other species, except for *C. japonica* form C *sensu* Versluys (1906), which Bayer (2001) implied was a separate species. Comparisons to other eastern Pacific congeners are made in Table 3.

**Etymology.**— This species is named in honor of Frederick M. Bayer, in acknowledgment of his many papers on the taxonomy of primnoid genera.

**Distribution.**— Known only from type locality off California and questionably form off Timor, 520 m (Versluys 1906).

### *Calyptrophora laevispinosa* Cairns, sp. nov.

Figures 1G, 14, 15.

**Material examined.**— Types.

**Types and type locality.**— Holotype: T885-A1, 46.683°N, 126.782°W (Gorda 1996 Flow, off Washington), 3107 m, 24 August 2005, 1.76°C, 9 branches from same colony and SEM stubs 1298–1300, 1304–1305, USNM 1102462, and 1 branch, CAS 175310.

**Description.**— The holotypic colony is now represented only by 10 branch fragments, the largest measuring 10 cm in length, however the *in situ* photograph (Fig. 1G) taken before collection shows a stately, flabellate colony approximately 32 cm in height and 59 cm in width, branches originating from the main branch just 1 cm from the basal attachment and filling approximately 160° of the flabellate plane. Branching is dichotomous and the branching axils are quite narrow, about 10–15°. The axis is straw colored, the calyces white. Calyces are arranged in whorls of 3 or 4 (usually 4) and face upward (Fig. 14A). There are 10–12 whorls per 3 cm branch length, the whorls spaced 1.2–1.3 mm apart, in the case of the types occasionally pushed together by post-collection trauma; the whorl diameter is 2.8–3.9 mm. Calyces are 1.5–2.0 mm in horizontal length.

The basal scales are 0.8–0.9 mm in height (exclusive of spines) and have rounded dorsolateral edges. Each basal scale bears a smooth (non-granular, non-ridged) spine on its dorsolateral margin that extends up to 0.55 mm. These spines are round in cross section, about 0.1 mm in diameter at the base. However, most of these spines also have a lower secondary spine or extension on their sagittal side, these spines only 0.12–0.15 mm in height and flattened in shape (Figs. 15C–D). The buccal scales are 1.0–1.05 mm in length and have rounded dorsolateral edges. Each calyx bears 4 (rarely 6) perfectly smooth, slender buccal spines, intact spines up to 0.6 mm in length and 0.1 mm in basal diameter (Figs. 14B, D, 15B, G). These spines are round in cross section, similar in size and shape to the primary basal spines, and aligned with the abaxial and outer-lateral opercular

TABLE 3. Characteristics of the three Eastern Pacific *Calyptrophora*.

| | *C.* cf. *antilla* Bayer, 2001 | *C. bayeri*, sp. nov. | *C. laevispinosa*, sp. nov. |
|---|---|---|---|
| Branch axils | 20–25° | 40–50° | 10–15° |
| Calyx length | 1.8–2.2 mm | 2.2–2.7 mm | 1.5–2.0 mm |
| Basal spines: length, cross section, sculpturing | 0.8–0.9 mm, round, ridged and serrate | 1.0 mm, flattened, inner surface ridges and serrate | 0.55 mm, round, smooth (accessory flattened tooth to abaxial side) |
| Buccal spines: number, length, cross section, sculpturing | 4, 0.5–0.7 mm, ridged and serrate | 6, 0.2 mm (triangular), flattened, irregular spines | 4, 0.6 mm, smooth |
| Infrabasals: number, height | 1 pair, 0.35–0.45 mm | 1 pair, 0.6 mm | 2 pair, 0.45 mm |
| Tip of operculars | Blunt | Blunt | Pointed (sometimes multi-tipped) |
| Coenenchymal scales | Elongate | Fusiform | Elongate |
| Distribution | Davidson Seamount, California, 1683–1763 m | Davidson Seamount, California, 1683 m; ?Timor, 530 m | Off Washington, 3107 m |

scales. The crescent-shaped infrabasal scales (Fig. 15F) are up to 0.45 mm in height ; the two adjacent coenenchymal scales are often reflected upward near the calyx, functioning as a second set of infrabasal scales (Figs. 14B, 15I). These secondary infrabasals are up to 2 mm in length.

The opercular scales (Fig. 15A) are triangular in shape, with a pointed tip, the abaxial operculars sometimes being bifid of trifid. The operculars are longitudinally creased above and keeled on their inner surface; their edges are finely serrate. The abaxial operculars are symmetrical in shape, 0.95–0.97 mm in length, with a L:W of 2.2–2.4. The 4 lateral operculars are only slightly asymmetrical, 0.71–0.90 mm in length, with a L:W of 1.7–2.1. The small adaxial operculars are symmetrical, about 0.7 mm in length, with a L:W of about 2. Tentacular sclerites are common, measuring up to 0.13 mm in length and 0.40 mm in width, curved in the plane of the lesser axis.

The coenenchymal scales (Fig. 15E) are elongate to elliptical in shape, usually with rounded ends, up to 1.3 mm in length. They are sparsely granular above and tuberculate below.

**COMPARISONS.**— *Calyptrophora laevispinosa* was compared to type material of all species in the *japonica*-complex, except for *C. japonica*, for which topotypic specimens from Japan were examined. It is perhaps most close to *C. spinosa* Pasternak, 1984 (Kapingamarangi Atoll, 910–1575 m), particularly in the shape of its basal spines, but C. *laevispinosa* differs in having cylindrical buccal spines, and smooth (not ridged) buccal and basal spines. Comparisons to other eastern Pacific congeners are made in Table 3.

**ETYMOLOGY.**— The species name (Latin *laevis* = smooth + Latin *spinatus* = spined) is an allusion to the smooth buccal and basal spines of this species.

**DISTRIBUTION.**— Known only from the type locality off Washington. At 3107 m, this is the deepest *Calyptrophora* ever collected.

### *Narella* Gray, 1870

**TYPE SPECIES.**— *Primnoa regularis* Duchassaing and Michelotti, 1860, by monotypy.

**DIAGNOSIS.**— Colonies dichotomously or pinnately branched, or unbranched. Calyces arranged in whorls, the calyces always facing downward. Each polyp enclosed by 3 or 4 pairs of unfused body wall scales (1 pair of basals, 1 or 2 pairs of medials, and 1 pair of buccals), 1–3 pairs of small adaxial buccal scales, and occasionally additional small, unpaired scales on the adaxial

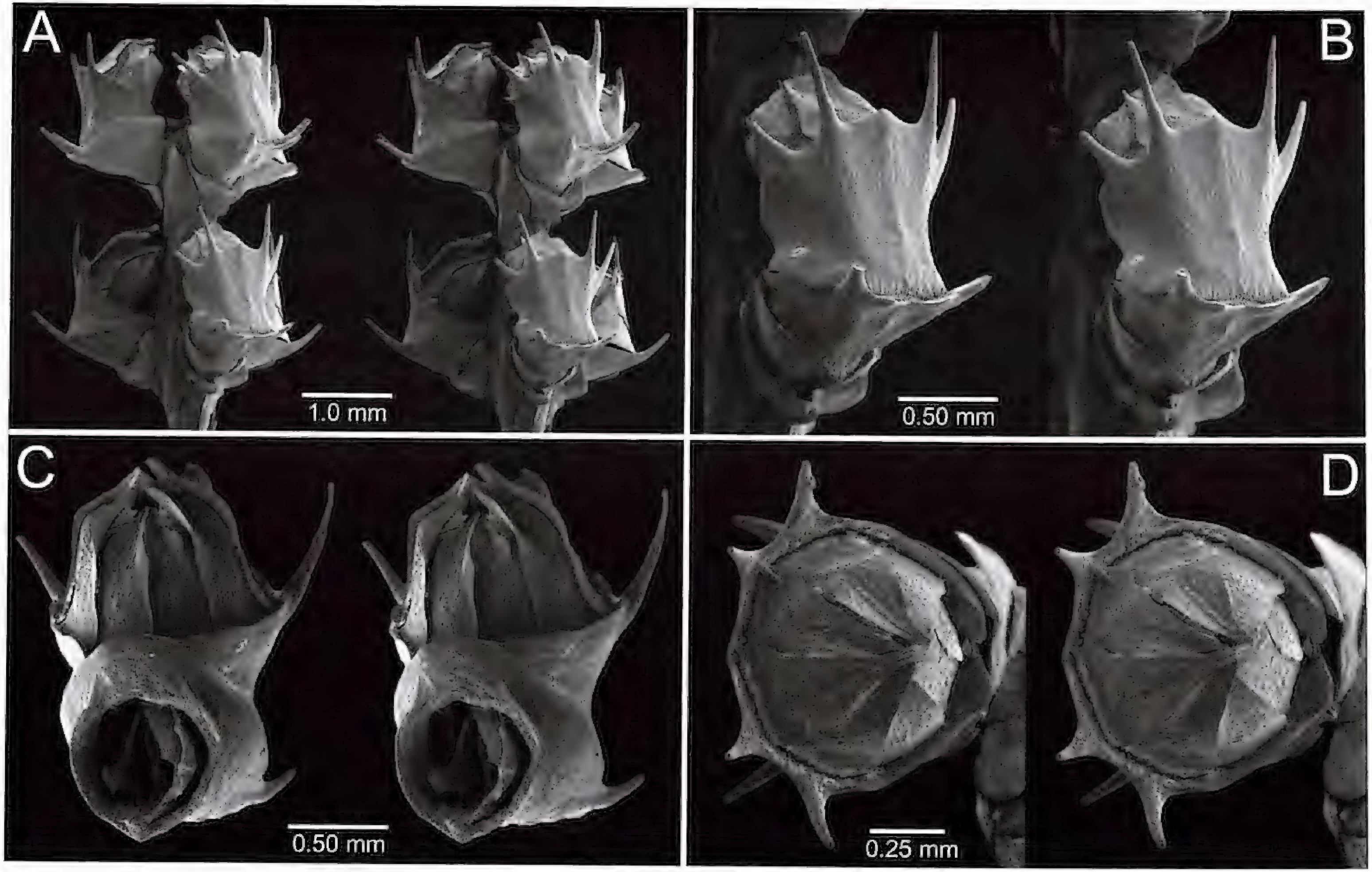

FIGURE 14. Stereo views of the holotype of *Calyptrophora laevispinosa:* A. Two whorls of calyces. B. Abaxial view of a calyx showing spines. C. Adaxial view of a calyx showing fusion of basal scales. D. Opercular view of a calyx. Scale bar for A, 1 mm; B–C, 0.5 mm; D, 0.25 mm.

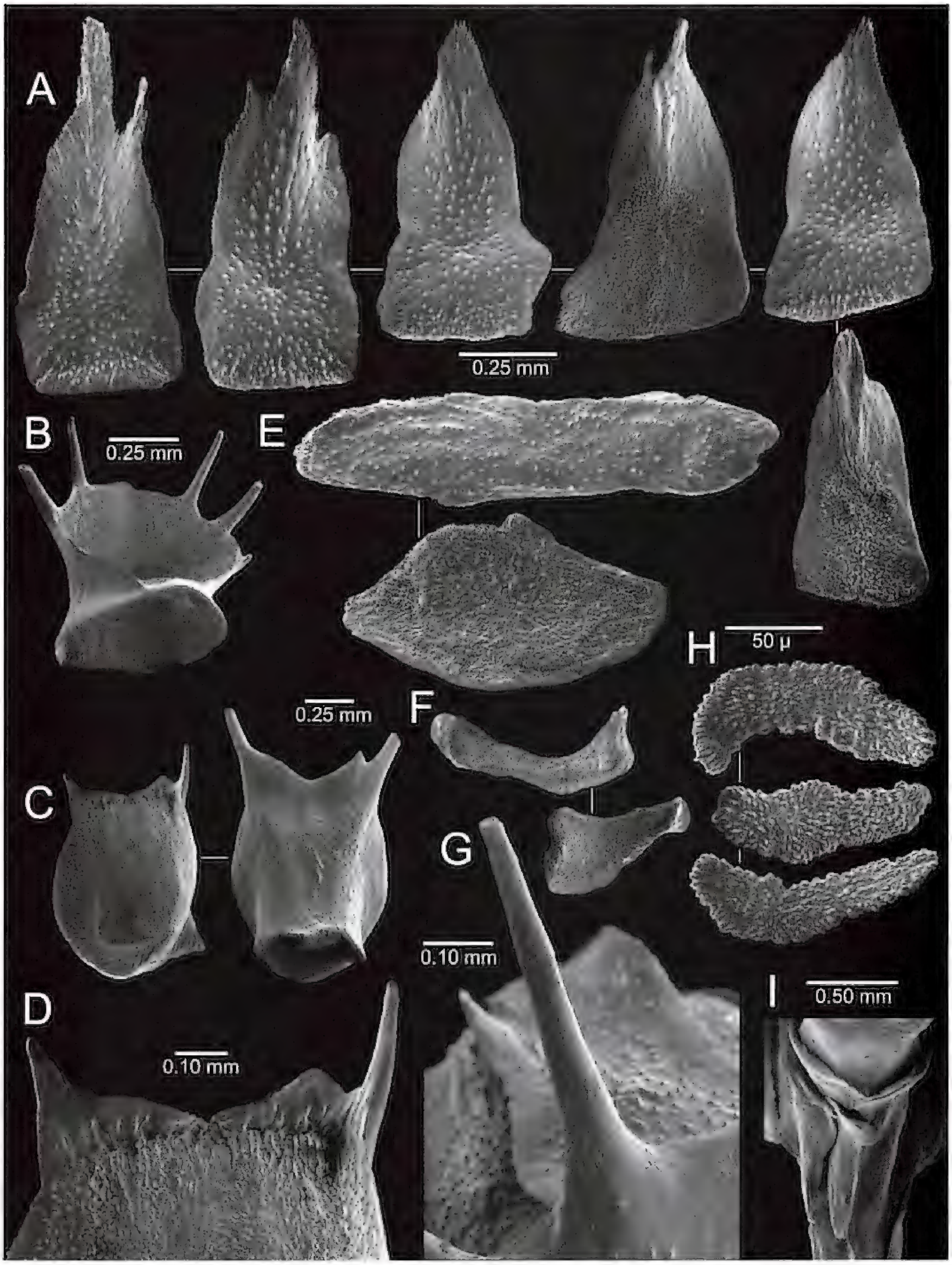

FIGURE 15. Sclerites from holotype of *Calyptrophora laevispinosa*: A, Six opercular scales. B. Adaxial view of a pair of fused buccal scales. C. Ad- and abaxial views of two pairs of fused basal scales. D. Inner view of broad basal spines. E. Two coenenchymal scales. F. Two infrabasal scales. G. Smooth buccal spines. H. Three curved pinnular scales. I. Articulation of infrabasal scales between basal and coenenchymal scales. Scale bar for A, E, 0.25 mm; B, 0.25 mm; C, F, 0.25 mm; D, 0.1 mm; G, 0.1 mm; H, 50 μm; I, 0.5 mm.

body surface. Distal margin of body wall scales often lobate of spinose; dorsolateral edge of basal scales often ridged. Operculum consists of 8 triangular scales, each with a pronounced medial keel on its inner surface. Coenenchymal scales usually elongate or elliptical in shape, often bearing tall vertical keels or ridges.

**Remarks.**— This is most prolific of the primnoid genera, consisting of 38 valid species (see listing by Cairns and Bayer 2008 [in press]). In addition to *N. bowersi* reported below, three additional branch fragments of *Narella* were collected from San Marcos Seamount, off southern California (2193 m), Rodriquez Seamount, off southern California (664 m), and "North Cleft", off Washington (2349 m) but these could not be identified due to their fragmentary nature; each one may represent an undescribed species. The genus has recently been studied by Cairns and Bayer (2003, 2008 [in press]) and Cairns and Baco (2007).

**Distribution.**— Known from all ocean basins from 55–4594 m (Cairns and Bayer 2008 [in press]).

### *Narella bowersi* (Nutting, 1908)

*Stachyodes bowersi* Nutting, 1908:577–578, pl. 43, fig. 6, pl. 48, fig. 2 (not pl. 43, fig. 5, which is *N. dichotoma*).
*Narella bowersi*.–Cairns and Bayer, 2008 (in press), figs. 1F, 12A–D, 13A–F (synonymy).

**Material examined.**— T1007-A3, 45.327°N, 130.385°W (Vance F Seamount, off Oregon), 2070 m, 29 July 2006, 1.90°C, 3 branch fragments, USNM 1102463.

**Types and type locality.**— The holotype is deposited at the USNM (25377). Type Locality: 23°05′N, 161°52′W (off Nihoa, Hawaiian Islands), 1758–1936 m.

**Discussion.**— Originally described from Hawaii, this species was recently reported from Endeavour Seamount off British Columbia at 2500 m (Cairns and Bayer 2008 [in press]). The specimen reported herein is simply a slight range extension for the species. Because it was described and illustrated so recently it is not re-described herein.

**Distribution.**— Hawaiian Islands and Pensacola Seamount, 1218–1758 m; Northeast Pacific seamounts (Endeavour and Vance) off British Columbia and Washington, 2070–2500 m.

## Acknowledgments

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# The Genus *Flabellina* Voight, 1834 (Mollusca: Opisthobranchia) from Bahía de Banderas (Pacific Coast of Mexico) with Ecological Observations, the Description of a New Species, and the Redescription of *Flabellina cynara*

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**Bahía de Banderas is located halfway down the Pacific coast of Mexico. Six sympatric species of the genus *Flabellina* have been found there, *F. cynara* (Marcus and Marcus, 1967), *F. telja* Marcus and Marcus, 1967, *F. bertschi* Gosliner and Kuzirian, 1990, *F. marcusorum* Gosliner and Kuzirian, 1990, *F. vansyoci* Gosliner, 1994 and *F. fogata* sp. nov., which is described here. The body color of *F. fogata* is semi-transparent red with a darker red digestive tract, the ceratal cores are bright fiery red with white opaque spots; rhinophores are irregularly and weakly annulate. The ecology of the six sympatric species was also studied with emphasis on seasonal patterns and habitats. This paper describes *Flabellina fogata,* its relationship with sympatric species and how it is distinguished from similar *Flabellina* species. In addition, new information on the anatomy of the incompletely described species, *Flabellina cynara* is given.**

KEYWORDS: *Flabellina*, Flabellinidae, sympatric species, eastern Pacific, nudibranchs.

## Resumen

**Bahía de Banderas se localiza en la parte central de la costa del Pacífico mexicano. Seis especies simpátricas del género *Flabellina* se han encontrado ahí: *F. cynara* (Marcus y Marcus, 1967), *F. telja* Marcus y Marcus, 1967, *F. bertschi* Gosliner y Kuzirian, 1990, *F. marcusorum* Gosliner y Kuzirian, 1990, *F. vansyoci* Gosliner, 1994 y *F. fogata* sp. nov. descrita en este artículo. El color del cuerpo de *F. fogata* es rojo a blanco semi-transparente con un tracto digestivo más obscuro; los centros de los ceratas son rojo fuego con puntos opacos blancos; los rinóforos son irregular y débilmente anulados. La ecología de las seis especies simpátricas se estudió con énfasis en los patrones temporales y hábitat. En este artículo se describe *Flabellina fogata*, su relación con las especies simpátricas y cómo se distingue de otras especies de *Flabellina* similares. Adicionalmente, se da nueva información de la especie *Flabellina cynara* cuya descripción original es incompleta.**

PALABRAS CLAVE: *Flabellina*, Flabellinidae, especies simpátricas, nudibranchs, Pacífico este.

Bahía de Banderas has been the subject of studies about the diversity of opisthobranch faunal composition (Sphon and Mulliner 1972; Bertsch et al. 1973; Ferreira and Bertsch 1975; Bertsch 1978, 1980; Bertsch and Kerstitch 1984). Hermosillo-González (2003) reported over 20 new distributional records for the bay. New species have recently been described for the area (Hermosillo and Valdés 2005; Gosliner and Bertsch 2004; Dayrat 2005). The composition is therefore well known but numerous species remain undescribed.

The family Flabellinidae has received considerable attention in the past 30 years (Miller 1971; Kuzirian 1979; Gosliner and Griffiths 1981; Gosliner and Kuzirian 1990; Gosliner and Willan 1991; Gosliner 1980, 1994). The phylogenetic and systematic relationships of the Flabellinidae have been examined by Gosliner and Kuzirian (1990) and from their analysis, it is apparent that the genus *Flabellina* contains numerous, morphologically diverse species. The morphological characteristics include a triserrate radula with a denticulate rachidian tooth and laterals; strong jaws, corners of the foot (propodial tentacles) are present and the anus is pleuroproctic in position. This genus has varied rhinophore shapes and usually bright body and ceratal colors. There are over 54 species of this genus described for all temperate and tropical seas, and they are present in a variety of habitats: reefs, rocks, and sandy bottoms where hydroids are present.

There are 14 described species of the genus *Flabellina* known for the eastern Pacific (Berhens and Hermosillo 2005). Of these, eight have been reported in Mexico (Hermosillo et al. 2006). During monthly surveys for a three-year period, six species were found regularly in 10 representative localities within Bahía de Banderas: *F. bertschi* Gosliner and Kuzirian, 1990; *F. cynara* (Marcus and Marcus, 1967), *F. fogata* sp. nov., *F. marcusorum* Gosliner and Kuzirian, 1990, *F. telja* Marcus and Marcus, 1967 and *F. vansyoci* Gosliner, 1994. The seasonal variation, feeding and spawning of these species are presented. In this paper, we describe a new species *F. fogata* sp. nov. and provide a redescription with additional information on the anal position, radula, and reproductive systems of the sympatric species *Flabellina cynara* (Marcus and Marcus, 1967).

## MATERIALS AND METHODS

Bahía de Banderas is located on the west coast of Mexico, in the states of Jalisco and Nayarit. Its large surface, over 1000 km², makes it the largest bay on the mainland Pacific coast of Mexico. Punta Mita and Cabo Corrientes, 42 kilometers apart, delimit Bahía de Banderas to the north and south, respectively. It has 115 km of coastline (Fig.1). Bahía de Banderas is located in the intermediate zone from 18° to 28°N between the colder waters from the north, where the seasonal thermal variations are rather large, and the warmer waters from the south, where the variations are small.

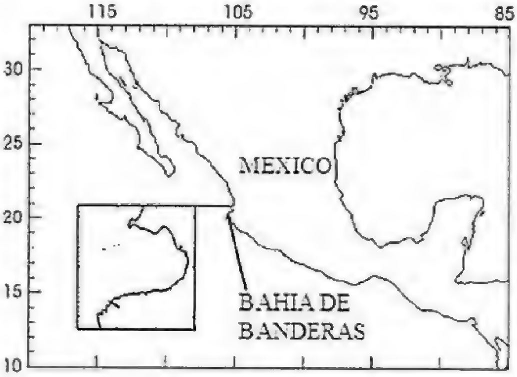

FIGURE 1. Map of Mexico with insert of Bahía de Banderas on the Pacific coast.

Ten localities were monitored monthly from February 2002 to April 2005. Observation, survey, and collecting were done by SCUBA diving in the shallow subtidal (between the depths of 1 and 25 meters) with immersions of 75 to 150 minutes. Temperature and rainfall were monitered and a Kruskal-Wallis test was done to determine the presence of any significant seasonality.

Species observed were photographed *in situ* with a Nikon Coolpix 995 digital camera in an Aquatica housing, utilizing an onboard YS-30 Sea&Sea strobe and an INON slave strobe. For small specimens, a 5× wet lens was used. All were later photographed in an aquarium using a

Nikon Coolpix 995 digital camera with two INON strobes; with white balance set to bright daylight. The color plate was prepared using Adobe Photoshop® 7.0, but the colors of the photographs were not corrected.

The specimens were relaxed in a 7% magnesium chloride solution in freezing sea water and preserved in 70% ethanol. We dissected the specimens by making a right lateral incision from back to front just above the foot. The internal features were examined and drawn using a dissecting microscope with a *camera lucida* attachment. The buccal mass was removed and placed in 10% sodium hydroxide until the radula and jaws were isolated from the surrounding tissue. The radula and jaws were then rinsed in water, dried, and mounted for examination. Scanning electron micrographs were made with a Hitachi S-4700FE SEM. Notes on the external features of the living animals were taken in the field under a dissecting microscope or a 10× magnification loupe.

## SEASONAL WEATHER PATTERNS AT BAHÍA DE BANDERAS

Because of its tropical nature, the landmass around Bahía de Banderas does not have the four typical climatic land seasons but only two, at least which are obvious: (a) rainy season during the summer (June–November) and (b) dry season (December–May). The water temperature undergoes dramatic changes throughout the year, with the lowest temperatures in April and highest ones in September and August (approximately 17.7 to 30°C). The month with highest recorded rainfall is August with an average of 46.6 cm (average annual rainfall for the bay is 149.6 ± 16.3 cm).

A Kruskal-Wallis analysis for water temperatures and rainfall demonstrated that there were actually three significantly different ($p<0.05$) climactic seasons within the bay (Fig. 2): (a) a dry-cold season (DC) February, March, April and May, during which the water temperature is the lowest (17.7 to 23.3°C) and there is little or no rainfall; (b) a wet-hot (WH) season during the months of June, July, August, September and October, with high water temperatures (26.6 to 30°C) and monsoon –like rain, and (c) a dry-warm (DW) season in the months of November, December and January, when the rainy season is over or almost over and the water temperature remains warm (23.3 to 27.7°C). This pattern was observed consistently during the period of study (April 2002 to April 2005).

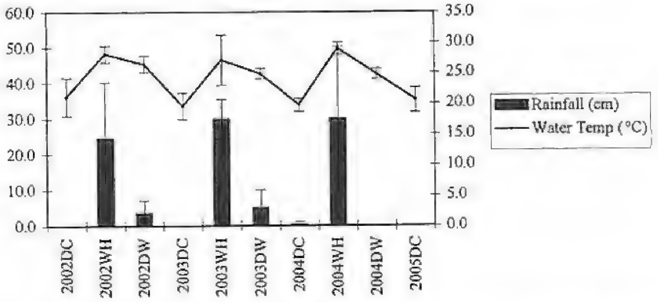

FIGURE 2. Water temperature and rainfall for Bahía de Banderas during the study period.

## FLABELLINID DISTRIBUTION AND ABUNDANCE AT BAHÍA DE BANDERIAS

Table 1 shows the accumulated abundance of each species observed from April 2002 to April 2005 in each of the 10 surveyed localities. Four of the six sympatric species constitute over 89% of the total of individuals of *Flabellina* recorded in Bahia de Banderas: *F. bertschi*, *F. cynara*, *F. marcusorum* and *F. telja*. These four species were present in all the survey sites. *Flabellina marcusorum* and *F. telja* are the most abundant species and together represent 63.9% of the individuals. They can occur in different localities and seasons possibly because both species appear to feed on several species of athecate hydroids, and this feeding flexibility may have enabled them to extend their feeding over a longer period. *Flabellina marcusorum* is consistently the most abundant throughout its known geographic distribution (Camacho-García et al. 2005; Hermosillo et al. 2006).

TABLE 1. Abundance of the six species of *Flabellina* in Bahía de Banderas.

| | Amarradero | Pared | Torres | Iglesias | Majahuitas | Iguana | Arcos | Lindomar | Viuda | Escondido | Total individuals | Abundance accum. | % Abundance | % Accumulated |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *F. marcusorum* | 171 | 144 | 137 | 219 | 197 | 140 | 197 | 90 | 464 | 23 | 1782 | 1782 | 35.7 | |
| *F. telja* | 30 | 18 | 82 | 121 | 257 | 411 | 210 | 211 | 24 | 45 | 1409 | 3191 | 28.2 | 63.9 |
| *F. bertschi* | 6 | 66 | 54 | 21 | 26 | 27 | 279 | 29 | 215 | 9 | 732 | 3923 | 14.7 | 78.6 |
| *F. cynara* | 0 | 11 | 13 | 3 | 5 | 6 | 64 | 172 | 241 | 39 | 554 | 4477 | 11.1 | 89.7 |
| *F. vansyoci* | 0 | 87 | 0 | 0 | 1 | 0 | 1 | 4 | 199 | 88 | 380 | 4857 | 7.6 | |
| *F. fogata* | 0 | 1 | 10 | 0 | 0 | 1 | 125 | 0 | 0 | 0 | 137 | 4994 | 2.7 | |
| **Totals** | **207** | **327** | **296** | **364** | **486** | **585** | **876** | **506** | **1143** | **204** | **4994** | | | |
| % | 4.1 | 6.5 | 5.9 | 7.3 | 9.7 | 11.7 | 17.5 | 10.1 | 22.9 | 4.1 | | | | |

## FLABELLINID SEASONAL PATTERNS

We used the number of individuals registered by hour of search (individuals/hour) to determine which species showed a seasonal pattern, testing with Kruskal-Wallis for significance. When a significant difference was found, a box-whisker plot and a multiple range test were used to find the groupings. The graph (Fig. 3) indicates species abundance and average water temperature (°C). A significant seasonal pattern ($p < 0.05$) was found for three of the species: *F. marcusorum, F. telja* and *F. vansyoci*. No pattern was observed ($p > 0.05$) for the other three: *F. bertschi*, *F. cynara* and *Flabellina fogata*. Prey was always athecate hydroids, usually attributable to the genus *Eudendrium*. Differences in shape and polyp color allowed the species to be readily distinguished in the field, but they were not formally identified because of the lack of expertise in the area.

*Flabellina marcusorum* exhibits an increase in abundance during WH, and diminishes in DW, with lowest abundance in DC and repeating the increase in WH. This means an increase in abundance occurs when water temperatures rise abruptly (approximately 5°C between May and June).

*Flabellina telja* was very abundant in 2002 and the first two seasons of 2003. Table 2 shows that the numbers diminished significantly during the rainy season (WH) and remained low in the rest of the study area. Iguana and Majahuitas were the sites with the greatest abundance of this species at the beginning of the study, both sites are close to rivers and streams. The rapid real estate

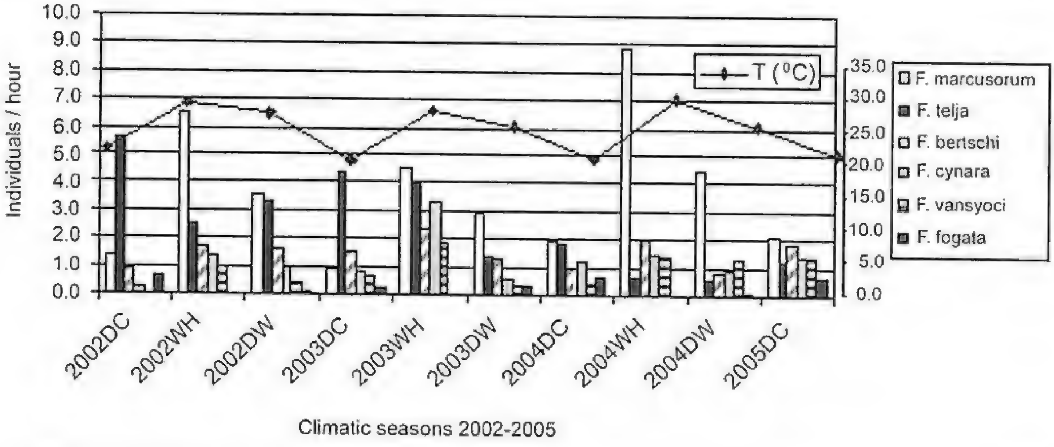

FIGURE 3. Abundances (individuals/hour) of *Flabellina marcusorum*, *Flabellina telja*, *Flabellina bertschi*, *Flabellina cynara*, *Flabellina vansyoci* and *Flabellina fogata*. Water temperature in °C.

TABLE 2. Natural history observations of the species of *Flabellina* in Bahía de Banderas.

| | *F. marcusorum* | *F. telja* | *F. vansyoci* | *F. bertschi* | *F. fogata* | *F. cynara* |
|---|---|---|---|---|---|---|
| **Known distribution** | Gulf of California to Ecuador; Caribbean | Gulf of California to Galápagos | Gulf of California to Panamá | Southern California to Panamá | Bahía de Banderas | Gulf of California to Panamá |
| **Distribution within Bahía de Banderas** | 10 sites | 10 sites | Viuda, Pared, Escondido. | 10 sites | Arcos | All except Amarradero |
| **Type of spatial distribution** | Usually solitary | Usually solitary | Gregarious | Gregarious | Gregarious | Usually solitary |
| **Seasonal patterm** | Yes, summer | Yes, winter | Yes, summer | No | Yes, winter | No |
| **Depths** | Shallow subtidal, below 1 m | Intertidal, shallow subtidal | Shallow subtidal, below 3 m | Subtidal below 10 m | Subtidal, below 15 m | Subtidal, below 4 m |
| **Swiming capability** | No | Yes, laterally bending the body | No | No | No | Yes, rowing its cerata |
| **Prey** | Athecate hydroid with white tentacles, purple-blue hydranths | Various species of athecate hydroids | *Eudendrium* sp. (bright orange) | *Eudendrium* sp. (red-orange) and others | *Eudendrium* sp. (red-orange) | Various species of athecate hydroids (including *Tubularia*) |
| **Prey specific** | No | No | Yes | No | Yes | No |
| **Color of egg mass** | Rose pink | Light pink | Rose pink | White | Orange | White |

development in the south of the Bay (between old Vallarta and Cabo Corrientes, which encompass these sites) has resulted in deforestation and an increase in sediments being carried down to the ocean by runoff and rivers, particularly during the rainy season. These sediments suffocate filter feeding animals, such as hydroids. It is possible that the hydroid favored by *Flabellina telja* is more susceptible and the diminished numbers of *F. telja* could indicate that this hydroid has not recovered in these locations.

*Flabellina vansyoci* has its greatest abundance in the WH season. *Flabellina vansyoci* is strictly a specialist, only found feeding and living on one ramified atecathe hydroid, likely a *Eudendrium* sp., with bright orange polyps, which has a stable population throughout the year but a very localized presence. The presence of *F. vansyoci* is limited to the three sites where the hydroid is found: Escondido, Viuda and Pared.

For *Flabellina fogata* a clear, but not statistically significant ($p > 0.05$), seasonal pattern is observed, with no individuals recorded during DW. Their presence is recorded during DC (when the temperature is about 19°C) and diminishes at the beginning of WH, when the water temperature increases. The cycle is clearly defined, however the relative abundances were too small to show a statistical difference. This species seems to have a fast growth because sexually mature adults are observed even at the beginning of the cycle and only a few small juveniles are found. This fast growth has been reported previously for aeolids. Rudman (1979) relates this to species feeding on transitional prey, in this case one which is present only during the colder water months (DC). The fast growth of a large population allows the egg-laying to proceed while the food source is still available.

## SPECIES DESCRIPTIONS

The key morphological features of the six sympatric species of the genus *Flabellina* observed regularly in Bahía de Banderas are listed in Table 3.

## Family Flabellinidae Voight, 1834

### *Flabellina* Voight, 1834

TYPE SPECIES: *Flabellina affinis* (Gmelin, 1791) by monotypy.

### *Flabellina fogata* Millen and Hermosillo, sp. nov.

Figures 4A, 5, 6.

ETYMOLOGY.— The word *fogata* means bonfire in Spanish and is given to this species because of its fiery red cerata.

MATERIAL EXAMINED.— HOLOTYPE: Los Angeles County Museum, LACM 30347, Los Arcos, Bahía de Banderas, Jalisco, Pacific coast of Mexico, 22 May, 2004, depth 19 m on hydroids collected by A. Hermosillo. PARATYPES: California Academy of Sciences, CASIZ 175007, 2 specimens, Los Arcos, Bahía de Banderas, 27 April, 2002, depth, 17 m on hydroids, collected by S. Millen. OTHER MATERIAL EXAMINED: 3 specimens, Los Arcos, Bahía de Banderas, 27 April, 2002, depth, 17 m on hydroids, collected by S. Millen.

EXTERNAL MORPHOLOGY.— This species is long and slender, slightly higher than wide and has a living length up to 15 mm (Fig. 4A). A typical preserved specimen measured 6 × 2 × 2.3 mm (l × w × h). There is a small notal brim in the area of ceratal insertions which is discontinuous in the cardiac region. The rhinophores are irregularly and weakly annulate, with approximately 9 annulations, appearing knobby in preserved specimens. Rhinophores are cylindrical, gradually tapering to a blunt apex and measure up to 2.3 mm long. The body color of living animals is semi-transparent red to almost translucent white with a darker red digestive tract. The rhinophores and oral tentacles are the same as the body; the rhinophores are slightly darker towards their bases.

The ceratal cores are bright fiery red and terminate in pale, translucent white cnidosacs (Figs. 4A, 5B). The outer surface is translucent red, including over the cnidosacs. Spots of opaque white pigment are scattered evenly along the entire lengths of the cerata. The density of spots varies. The cerata are up to 1.5 mm long, cylindrical with pointed tips; they are inserted in clusters along the well-developed, notal brim (Fig. 5A). The anterior cluster contains 12–20 cerata in four to five rows that bifurcate ventrally. The post-cardiac clusters contain fewer cerata, in two arch-like bifurcating rows in the first few clusters, posteriorly there is one row. The rows never have more than four cerata. There are 4–7 posterior clusters with very small gaps between each cluster. Because the clusters bifurcate towards the outside, the cerata are almost continuous ventrally.

The head (Fig. 5C) is small and round with a small mouth. It is slightly narrower than the foot. The oral tentacles extend from the anterior-lateral corners and are parallel to the oral surface. The tentacles are short, stout and flattened ventrally, up to 0.75 mm in length, shorter than the length of the rhinophores.

The foot (Fig. 5C) is bilabiate and thickened anteriorly with a wide anterior notch and short, thick propodial tentacles. The foot is narrower than the body with a well-developed flange and ends in a short, bluntly tapered trailing portion.

The genital aperture (Fig. 5A) is located under the middle of the first ceratal cluster. The pleuroproctic anal opening is on a small conical papilla under the 1st or 2nd ceras of the first post-cardiac cluster. The renal opening is slightly in front of the anus and posterior in the inter-hepatic space.

DIGESTIVE SYSTEM.— The mouth has two small posterior-lateral clusters of labial glands. There are small pedal glands on the foot. There is a smooth cuticle over a small muscular ring in front of the jaws. There are no oral glands. The buccal mass is slightly longer than wide, oval and wider posteriorly. The radular sac projects a small distance posteriorly from the buccal mass. The jaws are pale yellow. The jaw shape (Fig. 5D) is a broad triangle with a small dorsal flange and

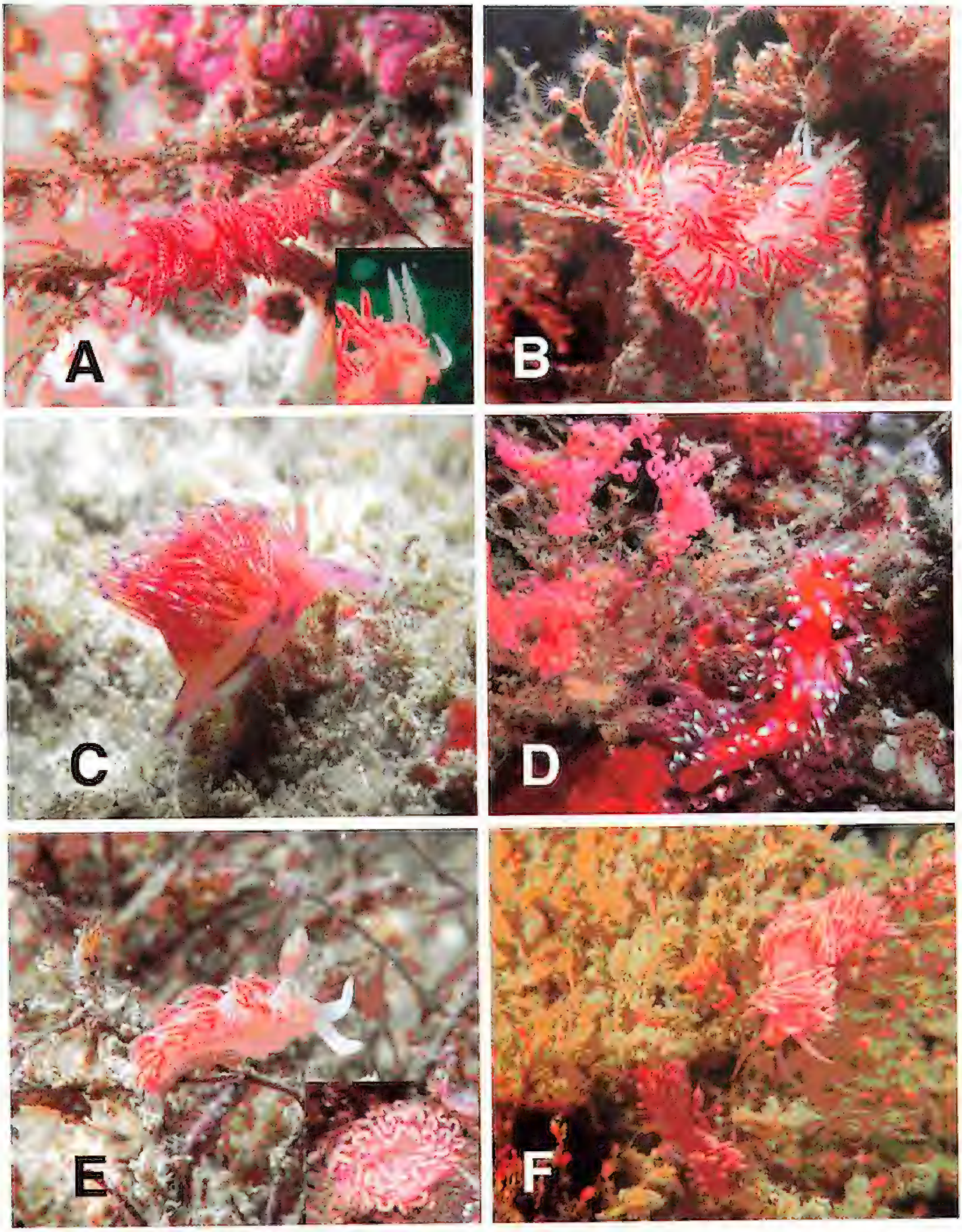

FIGURE 4. Living animals from Bahía de Banderas. A. *Flabellina fogata* sp. nov. Insert shows close up of head. B. *Flabellina bertschi*. C. *Flabellina cynara*. D. *Flabellina marcusorum* and spawn. E. *Flabellina telja*. Insert shows spawn mass. F. *Flabellina vansyoci* and spawn.

anterior articulatory knob. There is a well-developed masticatory flange bearing 2–5 rows of denticles, although only the outer row is well developed (Figs. 5D, 6A). The radula consists of 20–26 rows of teeth with the formula (1.1.1). The rachidian teeth (Figs. 5E, 6B) have a deeply incised base, long undepressed cusp and 5–7 denticles per side. The lateral teeth (Figs. 5E, 6B) are large, broad triangles with incised bases, slightly shorter on the inner edge. The inner edge is slightly curved and bears 11–17 denticles running from near the base almost to the tip.

The salivary glands are long and strap-like, orange in color and lie on either side of the stomach. They have a narrow duct, which enters the buccal bulb on either side of the ventral esophagus. The tubular esophagus is short, thin-walled, and wide. It enters a long, oval stomach. The right anterior hepatic duct has short branches, which bifurcate at the tips. The left anterior hepatic duct leaves the stomach slightly anterior to the right and has fewer cerata. The posterior hepatic duct runs ventral to the ovotestis. The short intestine curves down and up to a large anal papilla.

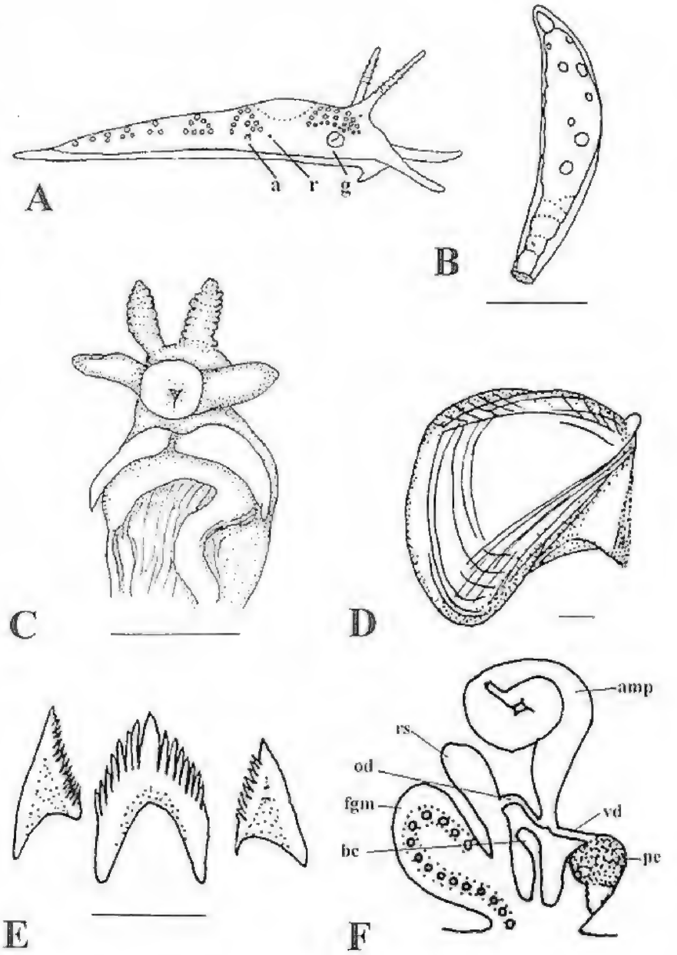

FIGURE 5. *Flabellina fogata* sp. nov. A. Right lateral view showing position of ceratal insertions. Stylized drawing. Key: a, anus; g, genital apertures; r, renal opening. B. Ceras showing opaque white spots. Scale bar = 0.5mm. C. Ventral view of head and foot. Scale bar = 1mm. D. One jaw. Scale bar = 0.1 mm. E. One row of radular teeth. Scale bar= 50 μm. F. Stylized drawing of reproductive system. Key: amp, ampulla; bc, bursa copulatrix; fgm, female gland mass; od, oviduct; rs, receptaculum seminis; pe, penis; vd, vas deferens.

NERVOUS SYSTEM.— The central nervous system consists of large, fused cerebro-pleural ganglia lying close together. There are long stalks to large rhinophoral ganglia located in the bases of the rhinophores. The large eyes are almost sessile. The statocysts are large. The pedal ganglia are oblong, slightly smaller than the cerebropleurals and attached with a longer commissure. The oval buccal ganglia lie a short distance apart beneath the esophagus. They have small gastro-esophageal ganglia.

REPRODUCTIVE SYSTEM.— The reproductive system is illustrated in Figs. 5F, 6C–D. The ovotestis forms continuous clusters posterior to the stomach. The female ancini are peripheral to the larger male ancini. The latter are joined by small collecting ductules and eventually unite to form a hermaphroditic duct. This duct enlarges into an ampulla with one and a half coils. The ampulla bifurcates into an oviduct and a vas deferens. The oviduct enters an elongate, serially arranged seminal receptacle. The distal oviduct enters the female gland mass at the albumen gland. There is a small, separate, long-stalked bursa copulatrix. The female gland mass has a large, creamy mucous gland, a white membrane gland and a central, granular albumen gland. The vas deferens is short and narrow. It enters a large penial bulb containing a bulbous, penis with glands proximally. Distally the muscular penis flares into a small disk and bears a row of short papillae (Fig. 6D). The male and female atria join a short distance before their common exit.

DISCUSSION OF *FLABELLINA FOGATA*.— Using the character set developed by Gosliner and Kuririan (1990), *Flabellina fogata* is a moderately derived flabellinid having external plesiomorphic features of a well-developed notal brim, and posterior anal placement. The cerata are in clusters, a moderately derived condition and the rhinophores have annulations. Internal plesiomorphic features are the lack of oral glands, presence of many rows of jaw denticles and a level rachidian cusp, although the latter is reduced in size from the elongate plesiomorphic condition The reproductive system is apomorphic in that it has a stalked proximal bursa, a short vas deferens and a discoid penis containing proximal penial glands (Gosliner and Kuzirian 1990). This reproductive system is similar to that of *Flabellina trilineata* (O'Donoghue, 1921), which has annulate rhinophores and three white lines and *F. verta* (Marcus, 1970), which has smooth rhinophores. These two species, the former from the eastern Pacific, the latter from the Caribbean, appear to be close to this new species as are the eastern Pacific species *F. verrucosa* (Johnson, 1832) and *F. cooperi* (Cockerell, 1901) which have a similar leaf-like penis with papillae (personal observation). The bright red-orange body, combined with irregular rhinophoral annulations, distinguishes *Flabellina fogata* from these species and combined with the reproductive structures, from all other *Flabellina* species wordwide.

There are 14 described species of *Flabellina* known from the eastern Pacific (Behrens and Hermosillo 2005), all are markedly different from *Flabellina fogata*. Only five species have known distributions that overlap that of *F. fogata* (Table 3, Fig. 2). *Flabellina marcusorum* has a purple-pink body with darker purple cerata with yellow cnidosacs. The rhinophores of this species are so distinct it cannot be confused with any other sympatric species: red colored, heavily papillate in the back and smooth in the front. *Flabellina bertschi* has red cerata like *F. fogata*, but the body is opaque white, the rhinophores are smooth, white colored and it is a small sized animal. *Flabellina vansyoci*, *F. telja*, *Flabellina cynara* and *F. fogata* have white spots on cerata and body, but these species can be easily separated from each other. *Flabellina vansyoci* can be can be reddish instead of its more usual rose-pink to purple and it also has white spots on the cerata, although the spots are larger, congested ones rather than fine dots. *Flabellina vansyoci* also has rugose markings on the rhinophores and the cerata are in clusters. Externally *Flabellina vansyoci* and *F. fogata* can be separated by the location of the anus, which is in the middle of the inter-hepatic space in *F. vansyoci* and posterior, under the first or second post-hepatic ceras in *F. fogata*. These two species can also be distinguished by their cnidosacs, which are translucent white in *F. fogata* and pink in *F. vansyoci*. Internally the radulae differ in that *F. vansyoci* has a depressed central cusp while *F. fogata* has an elevated cusp. *Flabellina fogata* lacks the large, compound oral glands found in *F. vansyoci*, which are visible as lateral white granulations in living animals. In the reproductive system, *F. vansyoci* has a trialuic system with two seminal receptacles and no bursa copulatrix, while *F. fogata* has a diaulic system with one seminal receptacle and a stalked bursa copulatrix. *Flabellina telja* is pale pink, has bulbous, heavily perfoliate rhinophores, thin, elongate oral tentacles, and bears white spots on the body as well as the cerata. *Flabellina cynara* is salmon-pink colored but unlike *F. fogata* it bears distinct purple markings on the foot, oral tentacles, and rhinophores; which are white and heavily perfoliate, and the cerata in the middle of the dorsum are longer than the length of the animal and are on elevated peduncles.

TABLE 3. External characteristics of the six species of *Flabellina* from Bahía de Banderas.

| Species | Rhinophores | Ground color | Color of cerata | Living size (mm) |
|---|---|---|---|---|
| *F. marcusorum* | Red, papillate posteriorly | Bright pink | Pink, purple and yellow | Up to 20 |
| *F. telja* | Yellow or brown, perfoliate | Light pink, white spots | Brownish pink | Up to 24 |
| *F. vansyoci* | Pink, verrucose | Rose pink | Rose pink, white spots | Up to 15 |
| *F. bertschi* | White, smooth | White | Reddish pink, white tip | Up to 8 |
| *F. fogata* | Translucent orange, annulate | Translucent orange | Red with white spots | Up to 15 |
| *F. cynara* | White with purple tips, perfoliate | Pink with purple markings | Salmon and purple, white spots | Up to 12 |

There are nine, non-sympatric *Flabellina* species which can occur in the eastern Pacific. Eight of them lack white spots on the cerata. *Flabellina amabilis* Hirano and Kuzirian, 1991 is white with red-orange cerata and white cnidosacs but the rhinophores are smooth. *Flabellina japonica* (Volodchenko, 1937) and *F. islandica* (Odhner, 1937) also have smooth rhinophores and continuous, not clustered, cerata. *Flabellina verrucosa* has verrucose rhinophores. *Flabellina trilineata* (O'Donoghue, 1921) has annulate rhinophores but can be distinguished by the three white lines on the body and stronger annulations on the rhinophores. *Flabellina triophina* (Bergh, 1894) has weakly annulate rhinophores, but a more elongate head and continuous cerata. *Flabellina iodinea* (Cooper, 1862) has heavily perfoliate rhinophores and cerata on pedicles. The dramatic purple, orange and red coloration is very different from *Flabellina fogata*. *Flabellina pricei* (MacFarland, 1966) has perfoliate rhinophores, cerata on pedicles and grey-white and yellow coloration that cannot be confused with *Flabellina fogata*. Only *Flabellina cooperi* has fine white spots on the cerata, but it has verrucose rhinophores and green ceratal cores that clearly distinguish it from the annulate rhinophores and red cerata of *F. fogata*.

All species with annulate rhinophores found worldwide, have recently been discussed by Millen and Hamann (2006). All species are clearly distinct from *Flabellina fogata*, the closest being *F. trilineata* from the Pacific, which has been discussed, and *F. dana* Millen and Hamann, 2006 from the Caribbean. *Flabellina dana* has a white body with a large opaque white mid-notal stripe and white sides. It lacks opaque white spots on the cerata and has a bulbous, tapering penis without glands (Millen and Hamann 2006; Millen 2007).

NATURAL HISTORY.— Known only in Bahía de Banderas, México at a limited number of sites, primarily Los Arcos (Table 1). It occurs at depths of 15–20 m. in small numbers, usually in the dry-cold season (Fig. 3). It appears to feed only on one species of *Eudendrium* with red-orange polyps (Table 2) upon which it lays a highly convoluted string of pink eggs, one per capsule. The spawn and prey hydroid are photographed in Hermosillo et al. (2006, sp. #188. pg.16).

### *Flabellina bertschi* Gosliner and Kuzirian, 1990

Figure 4B.

MATERIAL EXAMINED.— 1 specimen, Los Arcos, Bahía de Banderas, Jalisco, 26 April 2002, collected by S. Millen, rock wall on hydroids.

REMARKS.— We found that the external morphology of the present material agrees with the original description except that a small, discontinuous notal brim was found and only the anterior cluster of cerata appeared to be raised. Internally this species was as described. The penis was small and conical within an elongate, glandular sheath.

NATURAL HISTORY.— This species is found from southern California to Panama and through-

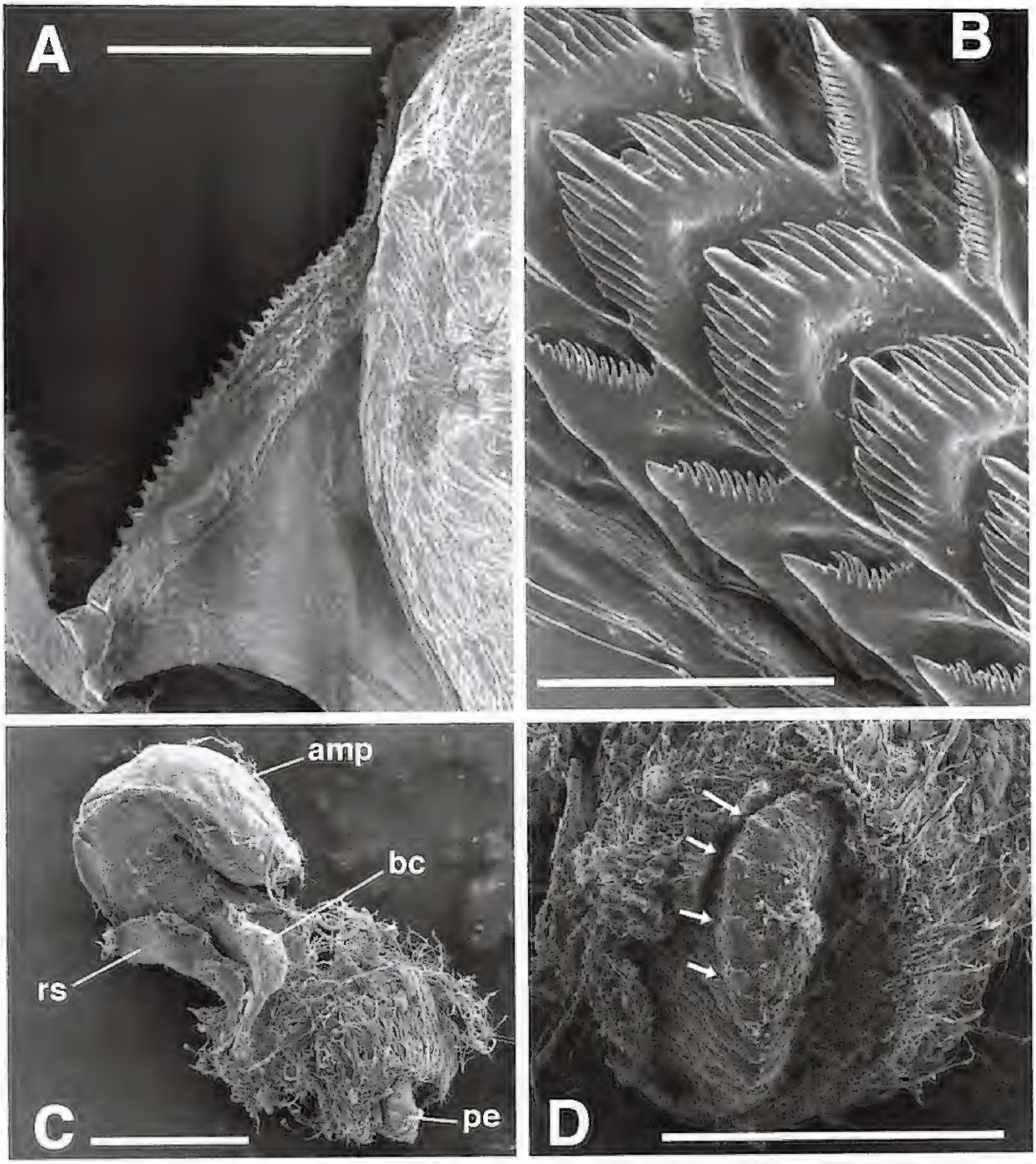

FIGURE 6. Scanning electron micrographs of *Flabellina fogata* sp. nov. A. Masticatory flange of a jaw. Scale bar = 100 µm. B. Radular teeth. Scale bar = 50 µm. C. Reproductive system. Scale bar = 500 µm. Key: amp, ampulla; bc, bursa copulatrix; rs, receptaculum seminis; pe, penis. D. Close up of the penis, arrows indicate papillae. Scale bar = 300 µm.

out Bahía de Banderas (Table 1). It occurs at depths of 10 m. or deeper, in great abundance throughout the year, with no significant season, but a slight peak in the wet-hot season (Fig.3). It feeds primarily on a species of *Eudendrium* with red-orange polyps (Table 2) upon which it lays a highly convoluted string of white eggs. The spawn and prey hydroid are photographed in Behrens and Hermosillo (2005, sp. #229, p. 105)

***Flabellina cynara* (Marcus and Marcus, 1967)**
Figures 4C, 7, 8.

Material examined.— 2 specimens, Sept 27, 1987 Isla Coronado, Bahía de los Angeles, Baja California, Mexico, collected by H. Bertsch. 3 specimens March 11, 1993, Panama, collected by A. Hermosillo. 2 specimens, May 4, 2002, Los Arcos, Bahia de Banderas, collected by A. Hermosillo. 2 specimens June 13, 2003, Bajo de la Viuda, Bahía de Banderas, collected by A. Hermosillo.

External morphology.— The external anatomy is illustrated by Marcus and Marcus (1967, fig. 71). The preserved animals examined ranged in length from 5–16.5 mm with cerata in the largest specimen up to 12 mm long. The width slightly exceeds the height. The body is wide in front and truncates abruptly into a narrow trailing portion. The rhinophores are perfoliate with up to 29 leaves extending most of their length, meeting at a thin line anteriorly and posteriorly. The cerata are lanceolate with narrow smooth cores and small cnidosacs. They are set onto slightly raised areas with a scalloped outer notal brim. There is one large, sloping pre-cardiac cluster and at least 8 post-cardiac clusters. In a 13 mm animal, the anterior cluster had 9 rows of 2–5 cerata, the posterior clusters had successively fewer rows and cerata per row.

The head is round with a vertical mouth and is narrower than the foot. The oral tentacles are long, lanceolate and only slightly flattened, originating parallel to the oral surface. The tentacles are longer than the rhinophores.

The foot is distinctly separate from the propodial tentacles, which have a bilabiate anterior margin with a wide gap in the upper lip. The split extends the full length of the propodial tentacles, which are slightly shorter than the width of the foot. The foot has a wide flange and abruptly tapers posteriorly into a pointed trailing portion, which has a slight dorsal crest.

The genital opening is posterior beneath the first ceratal cluster. Due to the length of this cluster, the genital opening is just anterior of the mid-part of the body. The renal opening is interhepatic and high on the side. The anus is far posterior, between the second and third post-cardiac clusters. Because of the scalloping nature of the notal flange, the anus appears hidden between the ceratal clusters, although it is located high on the side and not on the notal brim and therefore is pleuroproctic in position.

Digestive system.— Labial and oral glands are absent. The buccal mass is short and deep with a round lip disk against the yellowish brown jaws. The long masticatory margin is darker than the jaws. The jaws are as illustrated by Marcus and Marcus (1967, figs. 72–73, p. 222). The long radular sac points downward. Inside there is a thin, dark shelf leading to the infolded, tubular esophagus, which is also dark due to a chitin lining on the interior. The radula (Fig. 7A) had 16–19 rows of teeth. The rachidian teeth have a small elevated cusp and 5–11 denticles per side, with some denticles fused to the central cusp. The shape is as illustrated by Marcus and Marcus (1967, fig. 74). The narrow laterals had between 7 and 16 inner denticles. On some teeth no outer denticles were seen, on others 1–7 tiny denticles were present (Fig. 7B). The small salivary glands are short and sausage shaped. The long esophagus leads to a large, oval stomach. The two anterior hepatic ducts exit far back on the stomach, the posterior hepatic duct runs dorsal to the ovotestis. The intestine is large and long, ending on a small anal cone.

Nervous system.— The central nervous system has fused cerebro-pleural ganglia with large rhinophoral ganglia located just below the rhinophores. Two nerves leave each ganglia. The eyes are large and almost sessile. The small, oval, pedal ganglia are ventral with a visceral loop. The ganglia are very knobby with large ganglionic clusters, making the statocysts impossible to discern. The buccal commissure is only slightly longer than the visceral loop with two large, close together, buccal ganglia each with a small gastro-esophageal ganglion.

Reproductive system.— The reproductive system (Figs. 7C–D, 8) consists of an ovotestis

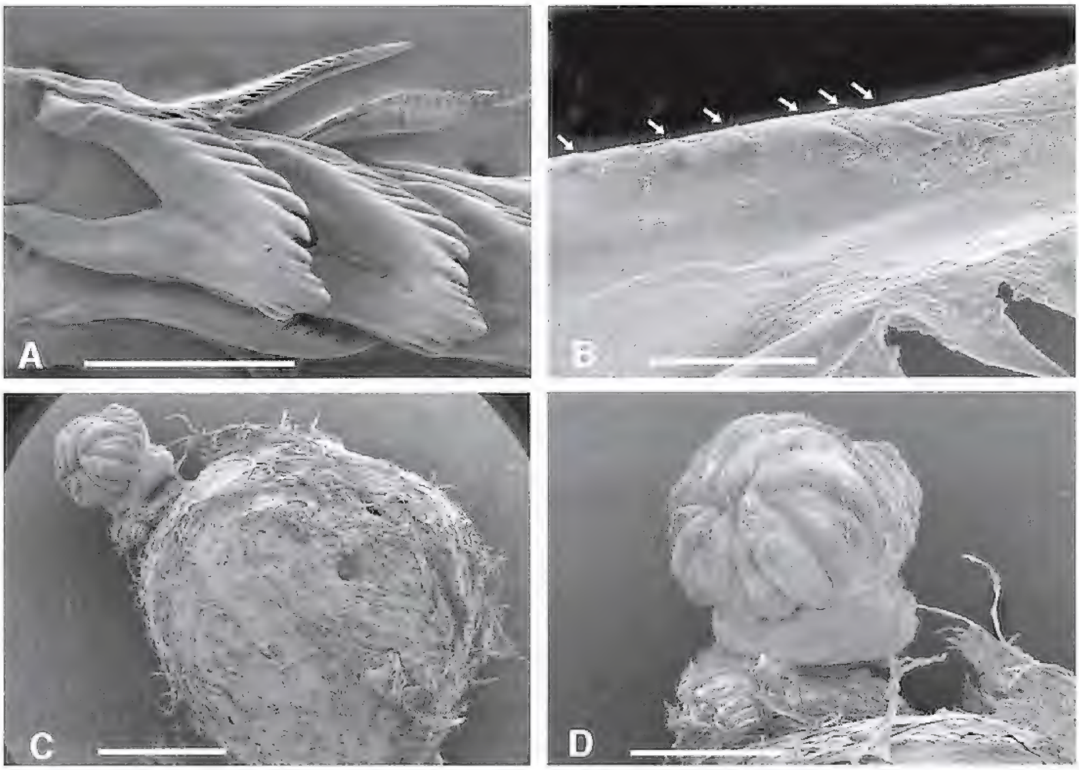

FIGURE 7. Scanning electron micrographs of *Flabellina cynara* (Panama). A. Central and lateral teeth. Scale bar = 200 µm. B. Lateral tooth showing large inner and small outer denticles, indicated by arrows. Scale bar = 20 µm. C. Internal, muscular atrium and everted penis. Atrium has a slice and pinhole on right (dissected specimen). Scale bar = 1 mm. D. Closer view of everted penis and warty preputum. Scale bar = 500 µm.

with large lobes. The peripherial female ancini with solitary eggs are sessile on the sacular male ancini. Each lobe has a small ductule, which joins to form the hermaphroditic duct. The hermaphroditic duct swells into a tubular, highly folded ampulla, then narrows slightly into a post-ampullary duct which distally divides into an oviduct and vas deferens. The narrow oviduct lies on the female gland mass and runs dorsally where two long ducts from tubular receptaculum seminis are inserted. These ducts twist around each other and terminate in two barely enlarged sacs. The oviduct loops ventrally and enters the female gland mass at its entrance to the atrium. The female atrium is large and striated, with an internal shelf-like cushion near its exit and a large chamber behind the cushion. The female gland mass does not have a separate duct but empties into the side of the atrial chamber. It is not large and is highly convoluted. The vas deferens swells a little into a tubular prostatic portion, which is smooth on the outside, although when full of sperm may be irregular in shape. The prostate forms a few loops and enters the large penial atrium. Inside this atrium there is fibrous tissue around the vas deferens, which ends at the base of an attached projection on the atrial wall (Fig. 7C). As the atrium everts, the preputium is folded and warty with a posterior groove leading to the opening of the vas deferens as illustrated by Marcus and Marcus (1967, fig. 75). As it expands, the warty preputum becomes inflated and globular and the posterior opening to the vas deferens everts to form a small, convoluted penial disk (Fig. 7D).

NATURAL HISTORY.— This species is found from the Gulf of California to Panama and throughout Bahía de Banderas (Table 1). It occurs at depths of 4 m. or greater in small numbers throughout the year, with no significant season, but a slight peak in in the wet-hot season which was pronounced in 2003 (Fig. 3). It feeds on a variety of hydroid species (Table 2). The white spawn mass has been observed but not illustrated.

Discussion of *Flabellina cynara*.— This distinctive species was described from Puerto Peñasco, Sonora, Mexico by Marcus and Marcus (1967). It has since been photographed many times, and its swimming behavior, noted in the original description, has been described in detail by Farmer (1970). Gosliner and Kuzirian (1990) in their cladogram character set added that the anus was posterior and the lateral teeth had both internal and external denticles. Gosliner (1991) in his discussion of a similar species, *F. iodinea* stated that the anus in *F. cynara* was situated in the posterior half of the body. We concur with this; the original description had mistaken the nephroproct for the anus. We also found tiny external denticles on some of the lateral teeth, which are illustrated here for the first time (Fig. 7B).

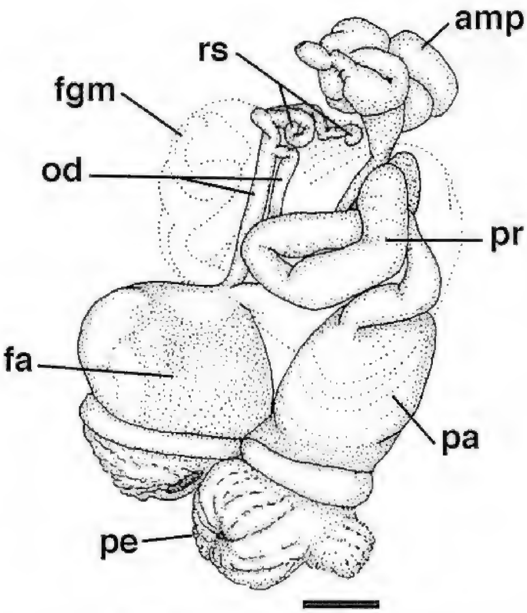

Figure 8. *Flabellina cynara* (Panama). Camera lucida drawing of the reproductive system. Scale bar = 0.5 mm. Key: amp, ampulla; fa, female atrium; fgm, female gland mass; od, oviduct; pa, penial atrium; pe, penis; pr, prostatic portion of vas deferens; rs, receptaculum seminis.

The general outline of the reproductive system is the same as that compiled by Marcus and Marcus (1967) from serial sections (fig. 75, p. 222). A number of details differ. The irregularity of the prostate is not granular, but only appears so when the contents are not evenly distributed. The warty preputum was not completely everted to show the small disk around the vas deferens, and the duct illustrated by them is actually a groove formed as it exits in a folded state. The long oviduct with its two tubular receptacula is noted here for the first time. The female gland mass is correctly shown as entering a large atrium which has a projecting cushion and a large chamber. This is unusual, but a similar situation is found in at least two other species, *Flabellina iodinea* and *Flabellina triophina* (personal observation). The chamber was interpreted to be a sessile bursa copulatrix by Marcus and Marcus for *F. cynara* and by Gosliner (1991) for *F. iodinea*. It is difficult to know if the striated chamber is homologous to the normal thin walled, balloon-like, bursa copulatrix or if it is simply an area to allow the large, discoid penis found on these three species a place to insert. However, the discoid penis of *Flabellina falklandica* (Eliot 1907) or *F. verrucosa* does not appear to require a similar chamber (personal observation).

### ***Flabellina marcusorum* Gosliner and Kuzirian, 1990**

Figure 4D.

Material examined.— 1 specimen, Majahuitas, Bahía de Banderas, 27 April, 2002, collected by S. Millen. 1 specimen, Los Arcos, Bahía de Banderas, 4 May, 2002, collected by S. Millen. 1 specimen, Los Arcos, Bahía de Banderas, 5 May, 2002, collected by S. Millen.

Remarks.— The materials examined agrees with the overall species description, however, we observed some color variations. Some specimens are darker, with an orange tint to the overall color.

In those specimens, the cnidosacs are bright yellow and they have an opaque yellow region on the dorsum. A small notal flange was observed. Internally the anatomy fit the published description. The color pattern leaves no doubt regarding the identity of the species.

NATURAL HISTORY.— This species is found from the Gulf of California to Ecuador, and the Caribbean. It is found throughout Bahía de Banderas (Table 1). It occurs at depths of 1 m. or greater, in large numbers throughout the year, and with a significant seasonal increase in the wet-hot season and decrease in the dry-cold (Fig. 3). It feeds on a variety of hydroid species, but particularly an athecate hydroid with white tentacles and dark purple-blue hydranths (Table 2). The highly convoluted, bright rose-pink spawn mass is illustrated for the first time in Fig.4D.

### *Flabellina telja* Marcus and Marcus, 1967

Figure 4E.

MATERIAL EXAMINED.— 2 specimens, Majahuitas, Bahía de Banderas, 27 April, 2002, collected by S. Millen. 1 specimen, Islas Marietas, Bahía de Banderas, 29 April, 2002, collected by S. Millen.

REMARKS.— This species was reviewed by Gosliner (1994) and was synonomised with *Flabellina stohleri* Bertsch & Ferreira, 1974. The material we examined agrees with the description of Gosliner (1994). We observed variation in the color of the rhinophores, which can be light yellow, pink or brown. The density of the white spots on the body and cerata also varies among individuals.

NATURAL HISTORY.— This species is found from the Gulf of California to Ecuador and throughout Bahía de Banderas (Table 1). It occurs in the intertidal and shallow subtidal in large numbers throughout the year. There is a significant seasonality, with a peak in the dry-cold season with numbers declining in the wet-hot and dry-wet seasons. Total numbers reduced during the study period (Fig. 3). It feeds on a variety of hydroid species (Table 2). The tightly coiled, light pink spawn mass is illustrated for the first time in the insert in Fig. 4E.

### *Flabellina vansyoci* Gosliner, 1994

Figure 4F.

MATERIAL EXAMINED.— 2 specimens, Paraíso Escondido, Bahía de Banderas, 17 June, 2003, collected by A. Hermosillo.

REMARKS.— The material examined agrees with the species description. A small notal brim was seen on this species.

NATURAL HISTORY.— This species is found from the Gulf of California to Panama but only in specific sites in Bahía de Banderas. It occurs in the subtidal at depths of 3 m or greater, in large numbers throughout the year. There is a significant seasonality, with a peak in in the wet-hot season and a slight decline in the dry-wet season (Fig. 3). It feeds on a bright orange athecate hydroid species, probably a *Eudendrium* sp., which is only found in isolated colonies in sites with rock walls and high energy. The dark rose-pink spawn mass and hydroid are illustrated in Hermosillo et al. (2006, species # 187, p. 115) and in Fig. 4F.

## DISCUSSION

Cladograms of the Family Flabellinidae have been produced by Gosliner and Kuzirian (1990) and Gosliner and Willan (1991). These deal with four of the species of *Flabellina* found in Bahía de Banderas. They consider *Flabellina telja*, *F. marcusorum* and *F. bertschi* to be highly derived, but members of different clades, and *F. cynara* to be moderately derived. *Flabellina cynara* still has the wider than high body shape adapted to soft bottom habitats but has a more derived reproductive system than basal flabellinids. Based on the characters used by Gosliner and Kuzirian (1990), *Flabellina vansyoci* is a derived species. The four most derived species found in Bahía de Banderas are *F. bertschi, F. marcusorum*, *F. vansyoci* and *F. telja*. They lack a notal brim, have oral glands and depressed cusps on the central teeth. *Flabellina telja* has cerata on high pedicles and the clade containing *F. bertschi*, *F. marcusorum* and *F. vansyoci* all have the derived feature of two seminal receptacles as does the more basal *F. cynara*.

*Flabellina fogata* is moderately derived (personal observation). *Flabellina fogata* has a shortened and wider prostate, as do the more derived species but its clustered cerata, notal brim, elevated cusps on the central teeth and lack of oral glands indicate that it is more basal. It appears to be closest to *F. verrucosa* and *F. cooperi* on the basis of its general anatomy and leaf-like, papillate penis and close to *F. trilineata* due to its penial glands and annulate rhinophores.

## ACKNOWLEDGMENTS

The fieldwork for this paper was completed with the support of Roberto Chavez Arce and Buceo Vallartech, ITMAR No. 6, and the Universidad de Guadalajara. We also thank the Department of Zoology and the Bio-Imaging Facility of the University of British Columbia. And, lastly, we gratefully acknowledge the contributions of Hans Bertsch, Kirstie Kaiser, Roberto Chavez, and Pedro Medina for their assistance in the field work and for critical reviews of the manuscript.

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# Xenaroswellanini, *Xenaroswelliana deltaquadrant*, New Tribe, New Genus, and New Species from the Cerrado of Estado de Goiás, Brazil (Insecta: Coleoptera: Carabidae)

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**A new tribe, genus, and species are recognized and described for the beetle family Carabidae. Xenaroswellanini new tribe, *Xenaroswelliana deltaquadrant* new genus, new species is known from a unique specimen found in 1974 at Lagoa des Pedras, west of the Rio Caña Brava, 160 km NE Brasilia, 15.067°S, 47.078°W, 492 m, Estado de Goiás, Brazil. While the species can be categorized within the Psydriformes – Psydrinae or Harplinae, its further classification is tenuous. Some attributes are similar to those of members of Psuedomorphini, a mymecophilus/isopterophilus lineage. The new species lives in the cerrado vegetation zone of eastern Goáis State and was found by sweeping vegetation at the edge of a large eutrophic marsh.**

**Uma nova Tribo, Gênero e espécie são reconhecidos e descritos para os besouros da família Carabidae. Xenaroswellanini nova tribo, *Xenaroswelliana deltaquadrant* novo gênero, nova espécie são conhecidos para um único exemplar encontrado em 1974 na Lagoa das Pedras, oeste do Rio Cana Brava, 160 km NE Brasília, 15.067°S, 47.078°W, 492 m, Estado de Goiás, Brasil. Enquanto a espécie pode ser aceita para os Psydriformes – Psydrinae ou Harplinae, sua classificação é pouco significativa. Alguns atributos são similares aos dos membros de Psuedomorphini, a linhagem mimecófila. Esta nova espécie vive na vegetação do cerrado, a leste do estado de Goiás e foi encontrada com a varredura da vegetação nas margens de um extenso charco eutrófico.**

**Una nueva Tribu, género y especie son reconocidas y descritas para los escarabajos de la familia Carabidae. Xenaroswellanini nueva Tribu, *Xenaroswelliana deltaquadrant* nuevo género, nueva especie, es conocida a partir de un único especimen colectado en 1974 en Lagoa des Pedras, oeste de Río Caña Brava, 160 km NE Brasilia, 15.067°S, 47.078°W, 492 m, Estado de Goiás, Brasil. Si bien, la especie puede ser categorizada dentro de los Psydriformes – Psydrinae o Harplinae, su clasificación posterior resulta poco clara. Parte de los atributos son similares a los de los miembros de Psuedomorphini, del linaje mymecophilus/isopterophilus. La nueva especie vive en la vegetación de Cerrado del este del estado de Goáis y fue encontrado barriendo con red la vegetación en los márgenes de un gran pantano eutrófico.**

Discovery of a strange new life form is an exciting human experience. If that human is also a biologist, then there is a challenge to recognize its place in the existing Linnean classification, know more about it, learn how to identify it, and then tell someone. To do the latter, at least accurately through time, a valid scientific name is required. When recognition and classification are not achievable after much literature and collection research and collegial interchange, one must then provide a suitable taxonomic context for the strange new life form, and provide the information necessary for others to recognize additional specimens of it, should they be discovered (*cf.* Ball and Shpeley 2002) and with the hope they will be found despite global landscape conversion and outright habitat destruction.

The subject of the present contribution on my studies of carabid beetles of the Western Hemisphere has resided in the Coleoptera collection of the U.S. National Museum of Natural History since 1974, undetected until earlier this year among the mixed lots of un-curated carabid beetles. The specimen was double-mounted sideways on a minuten pin, it is pale, and it is fairly small, hence it drew no attention from users of the collection, including me, until I began a general reorganization of the NMNH Carabidae as part of my Treatise series (Erwin 2007). At first glance, one is hard put even to recognize the specimen as a carabid beetle; it is so alien in its attributes (Fig. 1). There is nothing like it in the known Carabidae, yet upon observations of details, it has all the necessary structural features to place it amongst the more derived tribes, in Psydriformes — Psydrinae or Harpalinae, perhaps even close to the myrmecophilus members of Pseudomorphini.

The purpose of this paper is to make the taxon known, so that museum curators and field entomologists might be on the lookout for more individuals, both adults and immature stages, and what must be an extremely peculiar way of life in contrast to more "normal" carabid beetles. The species is putatively either myrmecophilus or isopterophilus because it shares certain features with known lineages of such disposition.

Darlington (1933) with his *Gehringia olympica*, Kavanugh and Nègre (1983) with their *Notiokasis chaudoiri*, and Ball and Shpeley (2002) with their *Ginema thomasi* were the last, since the early 20th century, to report a truly novel tribe of carabid beetles based on the description of a new species, rather than a reclassification of previously known oddities (*cf.* Basilewsky 1953, Bascanini; Erwin 1985, Amarotypini). Carabid beetles represent a well-known global lineage, thus not many new higher-level discoveries can be expected. However, when one does make such a discovery, it is incredibly exciting and challenging for us to search for more in under-explored and little known landscapes and microhabitats.

## MATERIALS AND METHODS

Length and width measurements follow the conventions suggested by Ball (1972) and Kavanaugh (1979). Apparent body length (ABL) is measured from apex of labrum to apex of longer elytron. Standardized body length (SBL) is the sum of the lengths of the head (measured from the apex of the clypeus to a point on midline at level of the posterior edge of the compound eyes), pronotum (measured from apical to basal margin along midline), and elytron (measured from apex of scutellum to apex of the longer elytron). Total width (TW) is measured across both elytra at their widest point (usually this is a measure of the left elytron doubled). The habitus images of the adult were made with a Leica M420 microscope and an EntoVision™ system. Precise measures were taken using the Archimed software embedded in the EntoVision™ system.

## ACCOUNT OF TAXON

### Western Hemisphere Genus and Species of Xenaroswellanini, New Tribe

*Xenaroswelliana deltaquadrant* Erwin, gen. et sp. nov., BRAZIL

PARTIAL KEY TO THE TRIBES OF CARABIDAE OF THE WESTERN HEMISPHERE
Modified from Erwin, Kavanaugh, and Moore (2002, revised 2004)

### Key to Tribes*

1 Intercoxal process of prosternum very broad, covering mesosternum. Scutellum concealed by median lobe of posterior margin of pronotum. Body almost circular in outline . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **Omophronini**, Bonelli 1810

1' Intercoxal process of prosternum not enlarged. Scutellum visible, at least in part. Shape of body various, but not circular . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2

2 (1') Mentum and submentum fused. Scape of antenna only partially evident in dorsal aspect when antenna not in repose. Head with short, deep antennal sulcus ventrally between eyes and mouthparts. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **Pseudomorphini**, Newman 1842

2' Mentum and submentum not fused. Scape of antenna visible from above. Head without short deep antennal sulcus, or with shallow channel for reception of scape . . . . . . . . . . . . . . . . . 2a

2a (2') Head semi-hypognathus, clypeus vertical, frons somewhat bulbous, mouthparts not visible in dorsal aspect; neck markedly constricted. Gena markedly swollen behind eye. Pronotum distinctly bow-shaped . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . **Xenaroswellanini**, new tribe

2a' Combination of attributes not as in 2a . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3

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* For continuation of key, see step 3 at Erwin, Kavanaugh, and Moore (2003)

### Xenaroswellanini Erwin, new tribe

TYPE GENUS: *Xenaroswelliana*, gen. nov., here designated.

**TRIBAL NAME.**— Based on the name of the type genus, with its derivation explained below.

**PROPOSED ENGLISH VERNACULAR NAME.**— Dissonant carabid beetles.

**DIAGNOSIS.**— Head semi-hypognathus, frons bulbous, mouthparts not visible in dorsal aspect, clypeus vertically oriented, edge at basal third of mandible with three stout anteriorly-curved setae; eye small, convex, orbit somewhat quadrate, posterior margin straight, others slightly rounded; gena markedly inflated behind eye; preocular lobes both above and below antennal insertion, the upper one small, the lower one markedly enlarged forming with the eye above a shallow sulcus for reception of the robust and long antennal scape. Antennomeres 1–3 elongate, 1–2 sparsely setiferous, without pubescence, antennomere 3 more setiferous apically, 4–11 short, subequal in length, with dense pubescence and an apical ring of longer setae. Mouthparts small and directed sub-ventrally at about 45°. Neck markedly constricted with large posterior collar. Pronotum bow-shaped with very wide lateral explanations, apically with recessed connection to neck, basally lobed. Elytra apically truncate, apical margin slightly sinuate. Abdomen with 6 visible sterna; last visible tergum with apical margin double-scalloped.

### *Xenaroswelliana* Erwin, gen. nov.

TYPE SPECIES: *Xenaroswelliana deltaquadrant* Erwin, sp. nov., here designated.

**DERIVATION OF GENUS NAME.**— The word "*Xenaroswelliana*" derives from the Greek, *Xenos*, plus a town in New Mexico, Roswell. Roswell, NM, became famous in the 1940s when a putative flying saucer landed there bringing with it guest aliens. *Xenos*, meaning guest or stranger, referees both to the strangeness of this lineage of carabid beetles and the likely possibility that it, and/or its larvae are inhabitants (guests) of ant or termite nests.

PROPOSED ENGLISH VERNACULAR NAME.— Dissonant carabid beetles.

DIAGNOSIS.— With the attributes of the tribe as described above and male with modified white adhesive setae on basal two anterior tarsomeres in two parallel rows. Mentum and submentum not fused; apical maxillary palpomere axinoform, apical labial palpomere slender, slightly longer than penultimate. Eye setiferous, setae long. Entire dorsal surface setiferous, setae long and stout, more densely amassed on bulbous frons, inflated gena, anterior and posterior pronotal margins, humeral margin, ventral posterior angle of pronotum, and apical margin of all sterna. Intervals and interneurs effaced, although trace of latter under high magnification and oblique lighting; elytral setae in eight parallel rows (including sutural) along midline of interneurs. Elytral margin broadly explanate.

GEOGRAPHIC DISTRIBUTION.— The geographical range of this genus is presently unknown given that a single specimen from Brazil is all that has been found, but undoubtedly, they occur elsewhere, if their habitat has not been completely converted to agriculture or desertified.

### ***Xenaroswelliana deltaquadrant*** **Erwin, sp. nov.**

Figures 1–5.

HOLOTYPE.— BRAZIL, **Goiás**, Lagoa de Pedras, west of Rio Caña Brava, 160 km NE Brasilia, 15.067°S, 47.078°W, 492 m, 30 October 1974 (L. Knutson) (NMNH:ADP109095, male).

DERIVATION OF SPECIFIC EPITHET.— The word "*deltaquadrant*" is a Star Trek "run-together" word denoting an area of the popular television program's Universe where the Starship Voyager gets lost; the word is feminine. While there in the Delta Quadrant, the Starship crew faces Species 8472, an alien life form likely from a "fluidic" parallel Universe to our own. The carabid species described herein presents similar mental challenges in understanding what must surely be a mysterious way of life in the cerrado of Goiás, Brazil. Another such mystery (*Cicindis horni* Bruch), took 100 years to solve (Erwin and Aschero 2004). Now, along comes another!

PROPOSED ENGLISH VERNACULAR NAME.— Delta-Q dissonant carabid beetle.

DIAGNOSIS.— With the attributes of the tribe and genus as described above and, overall color testaceous (Figs. 1–3), head slightly darker than pronotum and elytra; pronotum (Fig. 1) wider than long, rectangulate; apex and base deeply arcuate. Elytron with prominent humerus, broadly explanate and setiferous lateral margins, and truncate apex. Metathoracic wings fully developed.

DESCRIPTION.— (Figs. 1–4). *Size*: Small, ABL = 4.64 mm; SBL = 4.128 mm; TW = 1.78 mm. Pronotum ratio (W/L) – 1.66; elytron ratio (W/L) – 0.33; pronotum width/elytral length ratio – 0.53. With the attributes of the tribe and genus as described above and: *Color*: Head, pronotum, elytra and appendages testaceous. *Luster*: Dorsal surface markedly shiny. *Microsculpture*: Dorsal surface microsculpture effaced. *Head*: (Fig. 3) Mandible with shallow scrobe, margin tri-setiferous; labrum small, rectangulate, quadrisetose; clypeus small, rectangulate, hexisetose; frons bulbous, with numerous setigerous pores, setae markedly long and stout, directed anteriad. Occiput markedly convex, with same setal attributes as on frons. *Prothorax*: Pronotum (Fig. 1) markedly bow-shaped, disc convex and non-setose; lateral margins broadly explanate; anterior and posterior angles markedly prominent; lateral margins, base, and apex with numerous long stout erect setae; anterior margin fitted to vertical collar of constricted neck; posterior margin lobed; disk with longitudinal shallowly impressed line.

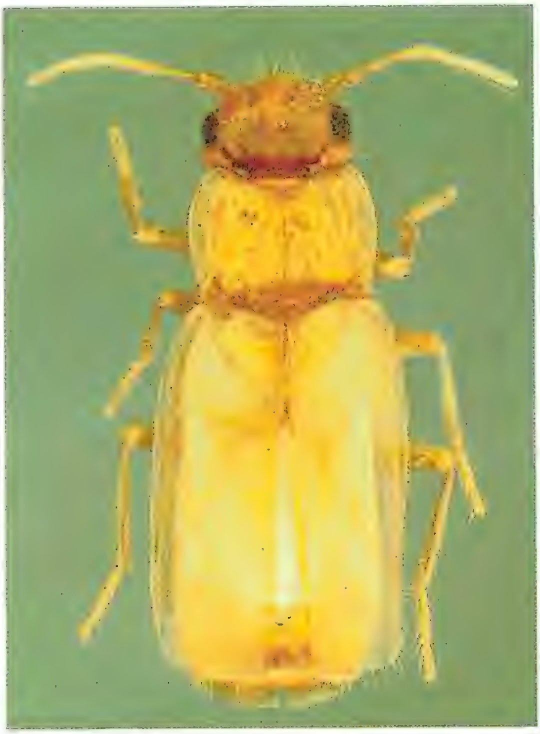

FIGURE 1. *Xenaroswelliana deltaquadrant* Erwin, male, dorsal aspect.

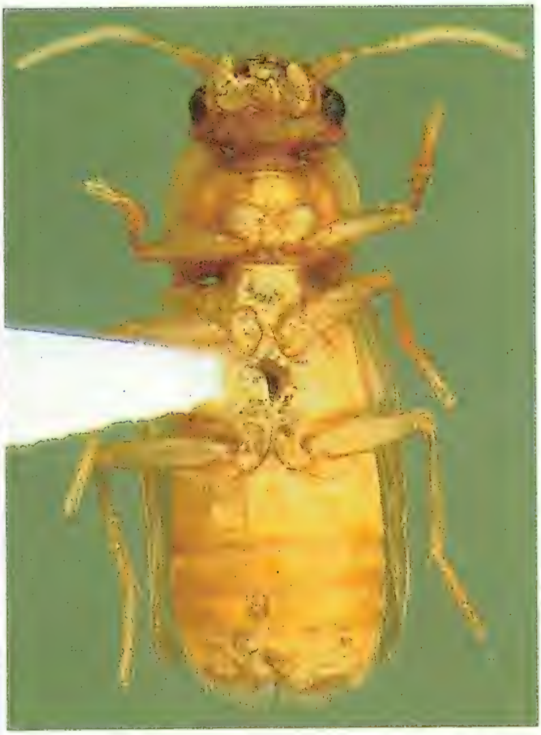

FIGURE 2. *Xenaroswelliana deltaquadrant* Erwin, male, ventral aspect.

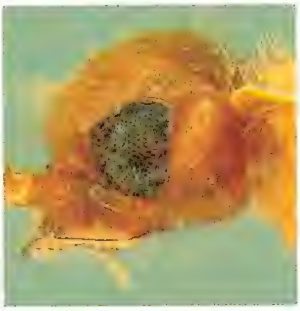

FIGURE 3. *Xenaroswelliana deltaquadrant* Erwin, male, head, lateral aspect.

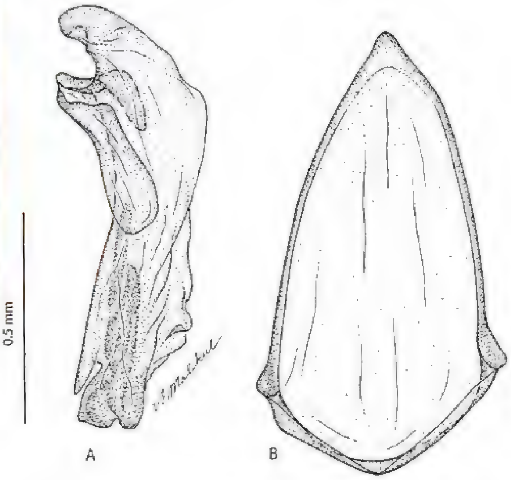

FIGURE 4. *Xenaroswelliana deltaquadrant* Erwin, male, A. aedeagus, left lateral aspect; B. Ring sclerite, dorsal aspect.

*Pterothorax*: Elytral interneurs micropunctate (difficult to observe); interval setigerous pores moderately closely spaced, moderately coarsely impressed. Metepisternum longer than wide, surface sparsely setiferous. Metasternum sparsely setiferous. Metathoracic wing fully developed, no doubt functional. Trochanter narrowed apically, acute. *Abdomen*: Sternum III-IV fused. All visible sterna sparsely setiferous on disk, each with numerous long stout setae along apical margin. *Male genitalia*: (Fig. 4) Phallus straight in dorsal *situ* aspect, apex pointed, left lateral margin very slightly arcuate at apical third; basal maw open, moderately deep. Parameres (Fig. 4): left more than twice length of right paramere and somewhat broader and truncate, distal margin of right markedly narrowed.

Endophallus with folding pattern and microtricheal fields, only. Ring sclerite an inverted "wishbone" with proximal end slightly produced, narrowly rounded.

**Dispersal potential.**— These beetles are macropterous and probably capable of flight. Accordingly, the species may be expected to be broadly distributed across a wide geographical range where its microhabitat persists in the face of massive landscape conversion to agriculture and neglect.

**Way of life.**— Adults putatively might be found in ant or termite nests or in the surrounding vicinity; larvae putatively could be nest inquilines. Members of *X. deltaquadrant* Erwin occur at midland altitudes in the cerrado vegetation zone at the margin of a large eutrophic marsh (5,100 meters diameter; Fig. 6). Adults are active in October and at least the male described here was active or resting on low sweep-able vegetation during the day (L. Kuntson, pers. comm.). Vegetation surrounding the marsh where the unique specimen was collected consists of *Cassia* sp., *Aeschynomene* ? *brasiliana* (Poir.) DC. (Leguminosae); *Setaria geniculata* (Lam.), *Paspalum* sp. *Sagitaria* sp. (Poaceae); *Heliotropium* sp. (Boraginaceae); *Ludwigia sedioides* (H. & B) Ham. (Onagraceae); *Echinodorus andrieuxii* (Hook. & Arn.) (Alismataceae); *Borreria* sp. (Rubiaceae).

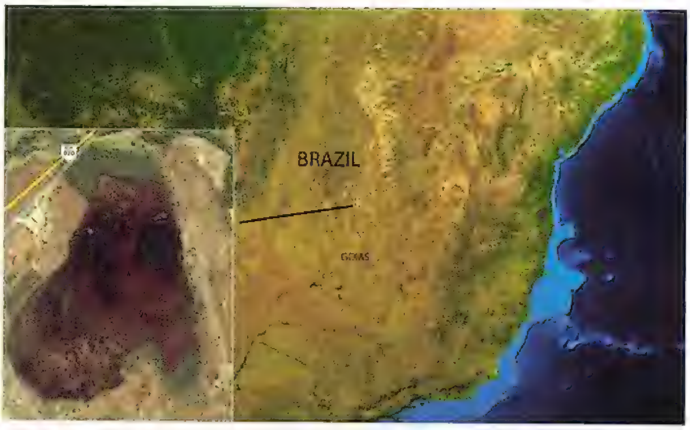

Figure 5. Geographic distribution map for *Xenaroswelliana deltaquadrant* Erwin with aerial view of marsh at the type locality along Brazil's Highway 20 in Goiás State, Brazil. Courtesy of Google Earth.

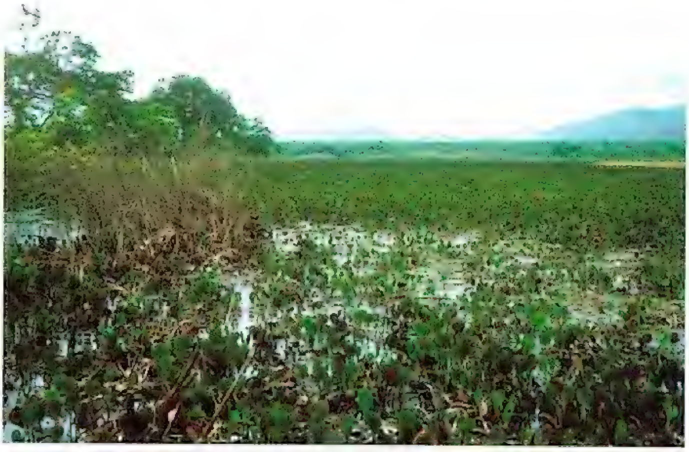

Figure 6. The vegetation and water body at the type locality in Goiás State, Brazil.

**Other specimens examined.**— None; the holotype is unique.

**Geographic distribution.**— (Fig. 5). This species is known only from the type locality.

## Discussion

The uniqueness of the single known specimen of this new taxon warrants its description for the purposes of promoting the discovery of more individuals for a more in-depth study of its relationships amongst the Carabidae and its natural history. In finding more individuals, attention must be given to recording its way of life in all aspects — possible host species if any, microhabitat, micro-vegetation zone, behavior, etc.

At present, from some of the attributes of the single individual described herein, I suggest there is a possible relationship with the enigmatic Pseudomorphini; however, that tribe's relationships are still unclear (Baehr 1992, 1997; Ober 2002; D. Maddison, pers. comm.) except that they are Harpalinae. Alternatively, are the apparent shared attribute tendencies with the pseudomorphines due to convergence because of similar selection pressures in life with ants or termites?

## ACKNOWLEDGMENTS

I thank Warren Steiner who dissected the male specimen and prepared images of the specimen, and Vichai Malikul who prepared the illustrations of the male genitalia; both are staff members in the Entomology Department, NMNH. I also express my deep appreciation to Valeria Aschero (CRICyT, Mendoza, Argentina) for translating the abstract into Spanish and to Marinez Marques for translating the abstract into Portuguese; to F. Christian Thompson for assistance with the proper Code applications on the new names; to Lloyd Kuntson who collected the specimen and kindly provided details and photos of the habitat. The publication of this paper was funded by the NMNH, Smithsonian Institution.

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# A New Species of Racerunner Lizard (Lacertidae: *Eremias*) from Iran

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**A new species of lacertid lizard, *Eremias kavirensis* sp. nov., is described from Isfahan Province in central Iran. The new species differs from all other known Iranian *Eremias* by having a subocoluar scale that does not reach the mouth, fringed toes, scales on flank distinctly larger than those of back, two rows of tibial scales, and its coloration. The known distribution of this distinctive new species is restricted to the Maranjaab sand dunes, Kavir Desert (Dasht-e-Kavir), Isfahan Province, Iran.**

KEYWORDS: *Eremias kavirensis*, Maranjab, Kavir Desert, Dahst-e-Kavir, sand dunes

The lacertid genus *Eremias* consists of 37 species endemic to Eurasian Palearctic deserts (Anderson, 1999; Rastegar-Pouyani and Rastegar-Pouyani, 2006). Seventeen species of *Eremias* are known from Iran, five of which are restricted to this country (*E. andersoni* Darevsky and Szczerbak, 1978; *E. lalezharica* Moravec, 1994; *E. montanus* Rastegar-Pouyani and Rastegar-Pouyani, 1999; *E. nigrolateralis* Rastegar-Pouyani and Nilson, 1998; *E. novo* Rastegar-Pouyani and Rastegar-Pouyani, 2006). We report and describe a sixth endemic species of *Eremias* from Iran. This distinctive new species is presently known from a single locality, the Maranjab sand dunes of the Kavir Desert (Dasht-e-Kavir), Isfahan Province (Fig. 1).

INSTITUTIONAL ABBREVIATIONS.— CAS, The California Academy of Sciences, San Francisco, California, USA; MMTT, Muze-ey Meli-ey Taarikh-e Tabiei (Tehran Natural History Museum), Tehran, Iran.

## DESCRIPTION

### *Eremias* Fitzinger, 1834

### *Eremias kavirensis* Mozaffari and Parham, sp. nov.

Figure 2.

ETYMOLOGY.— According to Arnold et al. (1978), "*Eremias* is a Greek noun meaning solitary devotee, and is related to *Eremia*, signifying an isolated place or desert." The epithet *kavirensis* is derived from the collection locality of the new species, the Kavir Desert (Dasht-e-Kavir), and the Latin '*-ensis*,' meaning 'from' or 'belonging to.'

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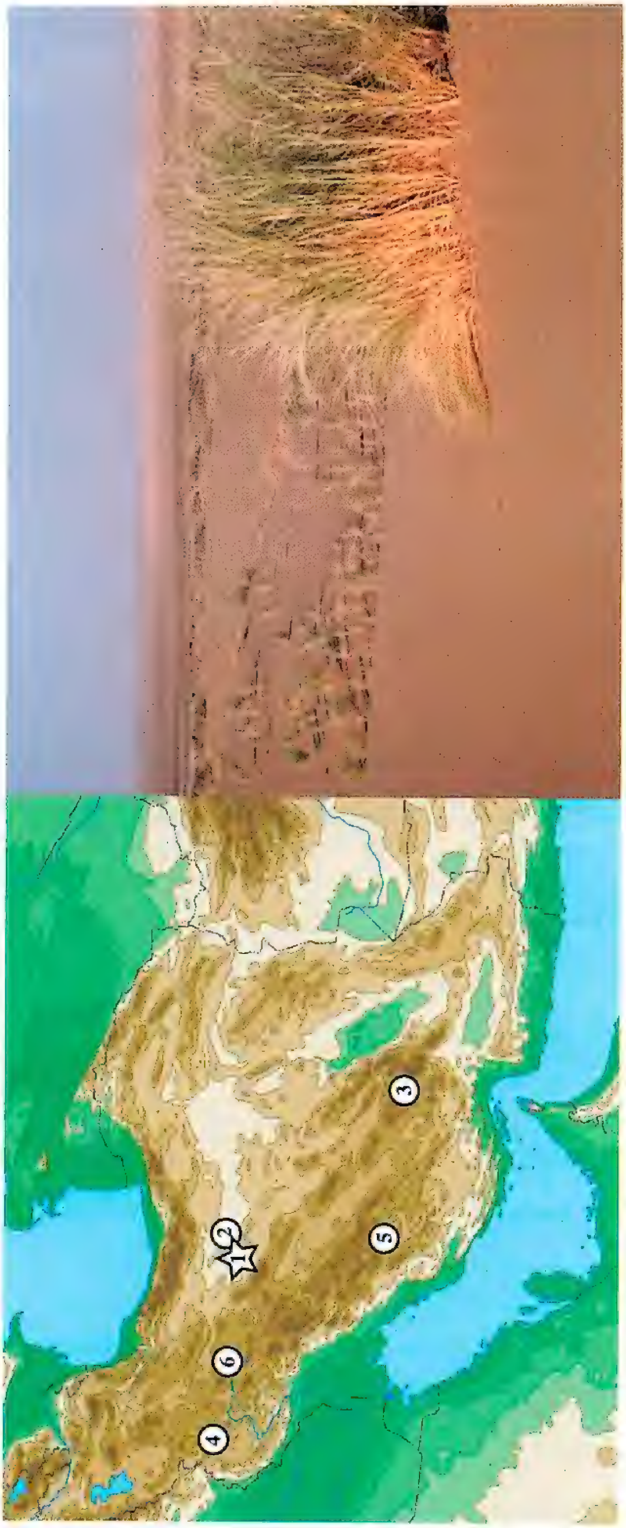

FIGURE 1. On the left, a map showing the localities of restricted-range species of *Eremias* endemic to Iran. 1(star): *Eremias kavirensis* sp. nov.; 2: *E. andersoni*; 3: *E. lalezharica*; 4: *E. montanus*; 5: *E. nigrolateralis*; 6: E. *novo*. On the right, habitat at the type locality of *Eremias kavirensis* sp. nov.

**MATERIAL EXAMINED.**— HOLOTYPE: (MMTT/AHI 1008) CAS 238636 [♂], 83 mm SVL, collected 22 June 2006; PARATYPES: (MMTT/AHI 1003) CAS 238641 [♀], 61 mm SVL, collected 22 June 2006; (MMTT/AHI 1004) CAS 238640 [♂], 61 mm SVL, collected 22 June 2006; (MMTT/AHI 1005) CAS 238639 [♀], 60 mm SVL, collected 22 June 2006; (MMTT/AHI 1006) CAS 238638 [♀], 62 mm SVL, collected 22 June 2006; (MMTT/AHI 1007) CAS 238637 [♂], 81 mm SVL, collected 22 June 2006; CAS 228522 [juvenile], 47 mm SVL, collected October 2002; (JFP 495) CAS 238642 [juvenile], 42 mm SVL, collected October 2002; (JFP 496) CAS 238643 [juvenile], 31 mm SVL, collected October 2002.

All material was collected from the type and only known locality, Iran: Isfahan Province: Maranjab sand dunes, 34°17′51″N, 51°50′57″E, (Fig. 1, 2A); AHI 1003–1008 were collected by the senior author (OM) and Esmaeil Saeedi; JFP 495–496 were collected by OM.

**DIFFERENTIAL DIAGNOSIS.**— Iranian *Eremias* can be assigned to four morphologically-defined subgenera (Szczerbak 1974; Anderson 1999). Although the monophyly of these subgenera remains to be tested with molecular data, they are useful morphological groupings for comparing our distinctive new form. By virtue of the subocular scale not reaching the mouth, *E. kavirensis* can be excluded from the subgenera *Eremias* and *Rhabderemias*. By virtue of having fringed toes, *E. kavirensis* can be excluded from the subgenus *Ommat-eremias*. Within the Iranian members of the subgenus *Scapteria*, *E. kavirensis* can be differentiated from *E.*

*grammica* by having enlarged tibial scales and from *E. acutirostris* by having scales of the flank larger than those of the back as well as having two rows of enlarged tibial scales instead of one.

**Description of Holotype.**— A large-sized *Eremias* with snout-vent length of 83 mm (largest known specimen of the type series). In life, the background color of the dorsum was sandy, yellowish-brown, and broken by grey transverse bars that are sometimes bordered with darker brown margins (Fig. 2A). There are dark brown spots on the head that are larger on the posterior head scales. The dorsal side of the limbs has enlarged light spots that, on the tibia especially, merge into semi-transverse stripes.

Cranial scalation (Fig. 2 B–D): Four pairs of submaxillary shields, with the first three pairs in contact, the fourth pair widely separated; first pair of submaxillary shields in contact with the men-

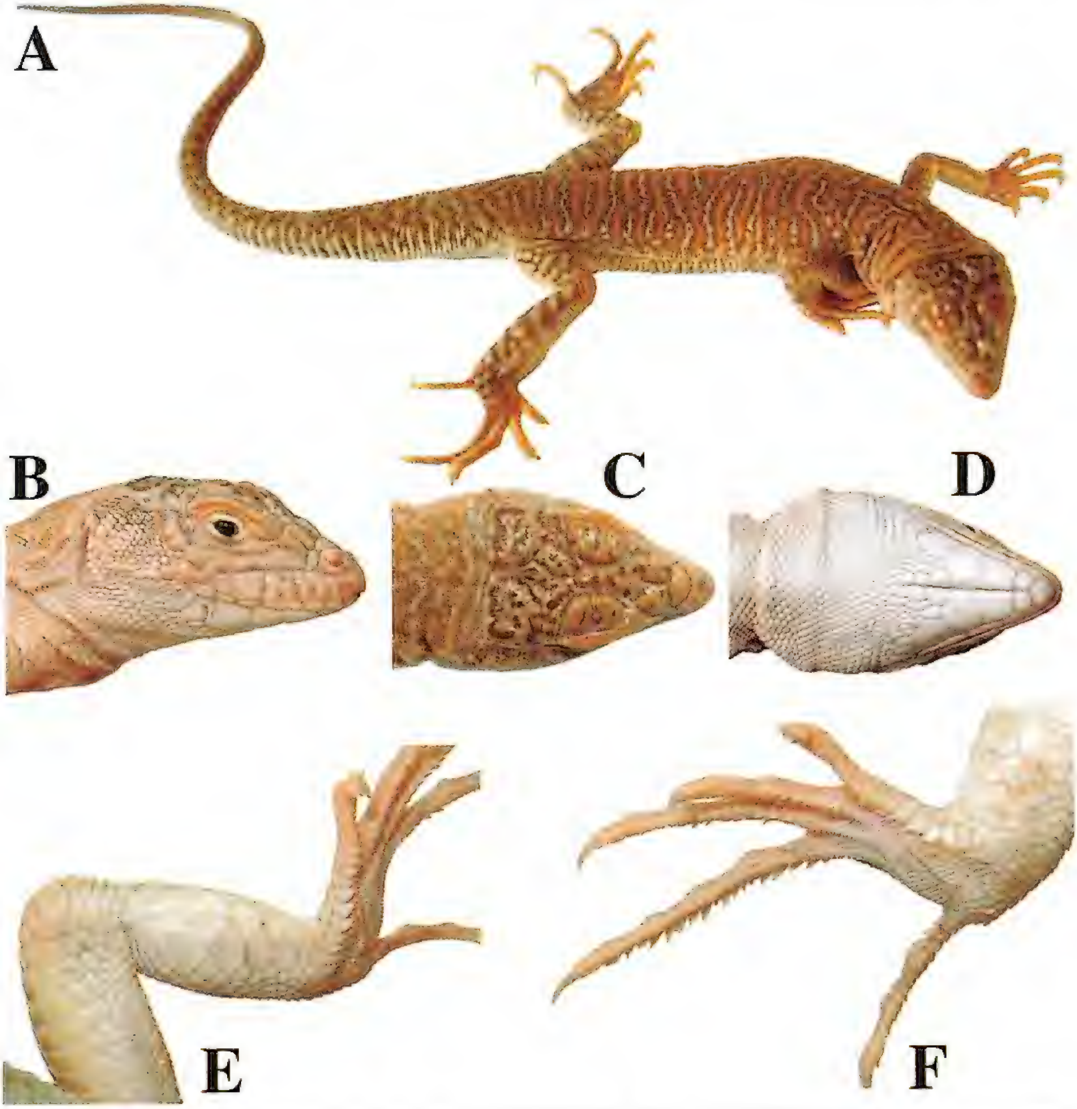

Figure 2. Morphology of *Eremias kavirensis* sp. nov. (MMTT/AHI 1008 = CAS 238636). A: Dorsal view of adult specimen showing coloration; B: Lateral view of head; C: Dorsal view of head; D: Ventral view of head; E: Ventral view of left hind limb; F: Ventral view of right hind foot.

tal scales anteriorly, with first and second infralabials laterally; the fourth submaxillary pair each in contact with the third pair anteriorly, surrounded by five granular scales laterally and posteriorly; seven sublabials; eight supralabials, seven of which are anterior to the subocular; subocular not bordering the mouth; three nasals, two of which are in contact with the rostral scale anteriorly; lower nasal resting on first and second supralabials as well as the frontonasal and first loreal posteriorly; the single fronotonasal is broader than long and laterally in contact with the first loreal and posteriorly with the prefrontals; dorsal head scales of adults are slightly convex; two prefrontals are in contact and almost as long as broad; prefrontals laterally contact the first and second loreals and posteriorly contact the frontal and supraocular; supraocular region, between the supraoculars and frontal, without any granules; frontal almost as long as prefrontal and frontonasal combined; frontal posteriorly in contact with the frontoparietals, laterally in contact with the supraoculars, and anteriorly contacting the prefrontals; two frontopariatals almost as large as one of the supraoculars, laterally in contact with the second supraocular and posteriorly contacting the interparietal and parietals; interparietal small and relatively lozenge-shaped, surrounded by the frontoparietals and parietals; two large parietals, almost as long as broad and contacting one another behind the interparietal; occipital is absent; two loreals; six supraciliaries, in contact with the supraocular; postocular elongate, surrounded by granules anteriorly; temporal region mostly covered by over 100 granular scales on each side that are larger towards the tympanum; tympanum vertically elongate, slightly larger than the orbit; no distinct supratemporal; subocular huge, narrower than long, and with a distinct ridge along the lower edge of the orbit; lower eyelids with a semi-translucent membrane.

Postcranial scalation: collar well pronounced, not serrated, made up of 10 scales, the two medial ones the largest; gular fold strongly developed, 24 gular scales; 18 longitudinal and 37 transverse rows of squarish ventral scales; anterior series of ventrals are somewhat irregular, median ventral longer than broad; dorsal scales are smooth, granular, becoming slightly larger laterally; 76 dorsal scales across the middle of dorsum, and about 190 scales in a single row from occiput to a point just above the vent; proximal caudals larger than posterior dorsals; caudals above the vent to approximately the 20th whorl are granular and from there to the end of the tail becoming large, elongate, and distinctly keeled distally, arranged in distinct whorls; 27 scales in the 20th whorl behind the vent; upper forearm covered dorsally by enlarged, juxtaposed, and almost lozenge-shaped scales; lower forearm covered with granules; upper hind limbs covered dorsally by granules, ventrally by large shields; tibia covered dorsally by slightly pointed granules, ventrally by two plates in a transverse row (Fig. 2E); 18 distinct fringes under the fourth toe, proximal part of the lower fourth toe containing a single row of lamellae (Fig. 2F); 19 femoral pores on each side, the two series separated anteriorly by a narrow space consisting of 8 scales; preanal region comprised of 24 large shields, the two medial ones being the largest; five plates in a longitudinal row fill the space between femoral pores to anterior edge of the vent.

VARIATION AMONG PARATYPES.— In juveniles, the coloration is different from adults; the transverse bars are uniformly dark. The venter and subcaudal surfaces of both young and adult are usually completely white although the groin is yellow in two adult female specimens (CAS 238639 [MMTT/AHI 1005], CAS 238636 [MMTT/AHI 1006]). The first pair of submaxillary shields contacts the first and/or second infralabials laterally; six or seven sublabials; seven or eight supralabials, five or six of which are anterior to the subocular; lower nasal rests on first, second, and, sometimes, third supralabials as well as the frontonasal and first loreal posteriorly; six or seven supraciliaries, in contact with the supraocular or separated from the supraocular by indistinct granules; collar well developed, not serrated, made up of 10–12 scales, the two medial ones the largest; gular fold strongly developed, 24–26 gular scales; 17–19 longitudinal and 36–38 transverse rows of squarish ventral scales; 75–80 dorsal scales across the middle of dorsum, and about 191–197 scales in a single row from occiput to a point just above the vent; proximal caudals larger than posterior dorsals; 27–28 scales in the 20th whorl behind the vent; upper forearm covered dorsally by enlarged, juxtaposed, and almost lozenge-shaped scales; 18–21 distinct fringes under the fourth toe, proximal part of the lower fourth toe containing a single row of lamellae (Fig. 2F); 19–21 femoral pores in each side, the two series separated anteriorly by a narrow space consisting of six or eight scales; preanal region comprised of 22–28 large shields, the two medial ones being the largest; five or six plates in a longitudinal row fill the space between femoral pores to anterior edge of the vent.

COMMENTS.— *Eremias kavirensis* is always found in the sandy microhabitat of the sand dunes and never in the surrounding gravelly areas. Based on this habitat preference, we hypothesize that *E. kavirensis* is endemic to the Maranjab sand dunes. The dune weed *Stipagrostis pennata* dominates the vegetation of the type locality (Fig. 1). Besides *E. kavirensis*, syntopic lizards include the widespread *Eremias fasciata, Bunopus crassicaudus, Teratoscincus keyserlingii, Phrynocephalus maculatus maculatus, Trapelus agilis*, and *Varanus griseus caspius*.

*Eremias kavirensis* is the fifth *Eremias* species known from the Kavir Desert (along with *E. andersoni, E. fasciata, E. persica*, and *E. velox*). *Eremias kavirensis* is geographically isolated from the morphologically similar species *E. acutirostris* and *E. grammica* from eastern Iran and adjacent countries. The description of *E. kavirensis* represents the sixth species of *Eremias* restricted to Iran and the Iranian endemic that is known from the Kavir Desert (Fig. 1). Given that all six Iranian endemics are known from restricted ranges (single localities), additional fieldwork has a high probability of either extending these ranges or else uncovering additional species heretofore unknown to science.

## ACKNOWLEDGMENTS

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# The Embiidina of Eastern Asia, Part I

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The embiid fauna of eastern Asia is rich and varied. Besides the Cretaceous amber fossil, *Burmitembia venosa* Cockerell, the extant fauna comprises eight families, of which four will be treated or proposed in Part II. Definition of some of the families is strengthened by inclusion of species occurring west of Myanmar. This, and future contributions on this fauna, almost entirely will be based on thousands of specimens the author collected and reared during several expeditions. Unfortunately, at present, research time and limited publication space permit only a résumé of this vast collection.

The richest part of eastern Asia's embiid fauna occurs in Thailand, but it diminishes southward into Indonesia. Strangely, the Philippines and New Guinea have only monotonously similar species of the widespread Indoaustralian genus *Aposthonia* Krauss, mostly treated in Part II. Because females are wingless and cannot fly, islands never connected to mainland lack embiids except for the few species inadvertently transported by man. Also, there are a few "weed" species randomly spread by man.

It is tantalizing to consider what additional taxa must occur in as yet unvisited places, such as the mountains of northern Myanmar, Laos, Vietnam, southwestern China, and other remote areas. However, author's advanced age and increasingly restrictive collecting permit requirements limit further exploration.

### Key to Embiid Families of Eastern Asia (Adult Males)

(Asterisk (*) indicates treatment will be in Part II)

1 Myanmar amber fossil . . . . . . . . . . *Burmitembiidae
Extant species . . . . . . . . . . 2
2 Wings with anterior media vein forked . . . . . . . . . . 3
– Media vein not forked . . . . . . . . . . 7
3 Distal segment of left cercus not fused to the basal segment . . . . . . . . . . 4
– Distal segment at least partly fused to the basal segment . . . . . . . . . . 6
4 Minute species (body length less than 10 mm). Inner base of left hemitergite (10 L) fused to medial sclerite (MS) which is extensively extended forward as a triangular point beneath ninth tergite. (9) . . . . . . . . . . *Teratembiidae
Larger species (body length 10-18 mm). Base of tenth tergite (10) more or less straight, not greatly extended forward beneath ninth tergite . . . . . . . . . . 5
5 Hemitergites (10 L and 10 R) broadly separated, intervening cleft largely filled with a large sclerite (MS) . . . . . . . . . . *New Family
– Hemitergites not broadly separated . . . . . . . . . . Embiidae
6 Antennal segments without usually long, wavy setae. Wings maculated with irregular white areas . . . . . . . . . . *Embonychidae

– Antennal segments with unusually long, wavy setae. Wings without irregular white areas . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *New Family

7 Unusually small species (body length 5 mm). Left cercus with distal segment fused to apex of basal segment . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *New Family

– Larger species (body length 10-18 mm). Left cercus with distal segment not fused to the basal segment. . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . Oligotomidae

## Embiomorpha, new infraorder

### Embiidae Burmeister, 1836

**Distribution.**— African and Indian regions. Many genera from other regions, particularly Neotropical, that were once and currently placed in this family, will be assigned to other families.

**Diagnosis.**— Adult males monochromatic brown, alate or apterous, robust, body length averaging 12 mm. Cranium longer than broad, eyes small. In most species the mandibles are elongate, parallel-sided, with distal teeth usually curled ventrad, subapical teeth usually obscured by the dorsals. Antennal setae short. Wing vein MA always forked. Hind basitarsi short, with one or two medial papillae. Terminalia hemitergites narrowly spaced; medial sclerite (MS) inconspicuous. A flap-like projection (MF) partly extends over epiproct. Cerci two-segmented, basal segment often globose, always echinulated, at times bilobed.

Only the genus *Oedembia* has been found in NE Myanmar. Otherwise, this is a large genus with many closely related species, one of which, *O. dobhali* from southern India, was erroneously placed by the author in a subgenus, *Parembia*, of *Embia* (Ross 1950). The author has chosen the most distinctive new species of *Oedembia* from India as the best type species of the new genus.

### *Oedembia* Ross, gen. nov.

Type species: *Oedembia dilatamenta*, Ross, sp. nov., present designation.

**Distribution.**— India, Nepal, Pakistan, and Myanmar.

**Diagnosis.**— Males with basic characters of Embiidae, but the submentum is swollen (the basis of the generic name). The lobe of the basal segment of the left cercus is unusually large, triangular, with a dorsal, horizontal fold. The right tergal process (10 RP) is very long, sharp, folded forward beneath caudal margin of 10 R. Both paraprocts and the hypandrium lobe are short, sclerotic. Hind basitarsus short with two very large papillae.

Females: Without noteworthy characters, except the two basitarsal papillae.

**Remarks.**— For the present, the above generic description will augment the description of the type species. The genus is most closely related to *Parembia* Davis, 1939, treated in error by the author as a subgenus of *Embia* Ross, 1950. The author now considers *Oedembia* a distinct genus because of its swollen submentum, more elongate left tergal process, shorter hypandrium process, much shorter left paraproct and longer, acute right tergal process. A transverse dorsal fold on the basal segment of the left cercus lobe is also absent in *Parembia*. There are also other distinctions.

### *Oedembia dilatamenta* Ross, sp. nov.

Figure 1.

**Holotype.**— Male, on slide, CAS. India: 4 mi W Kochagaon, 75 m elev., Assam. Matured in culture 22-IV-1963 (E.S. Ross).

**Description.**— Large, body length 14 mm, alate. Characters are described for the genus. Head broad, quadrate; broader than long; submentum dark, transversely rugose, broad at base, becoming narrowed and elevated anteriorly. Body length 14 mm; forewing length 10 mm, breadth 2 mm.

FEMALE: Without significant characters.

PARATYPES.— Many topotypic males (CAS), to be deposited in major entomological collections.

ADDITIONAL RECORDS (CAS).— Assam: numerous specimens from near Shillong, 1000 m elev.; Assam: Meleng Forest Reserve, 100 m elev. (males from this locality are smaller with a paler prothorax); Bengal: Badantan Forest Reserve, near Darjeeling, 1000 ft. elev.; Bengal: Ging, near Darjeeling, 4500 ft. elev.; Bangladesh: Ichamati Forest Reserve, 20 mi E of Chittagong; Nepal: 10 mi SW of Sopiyang, 1800 m elev. The above lots, and many more stocked in alcohol vials, indicate that this is a widespread species requiring future analysis. An apparently new species was collected in Myanmar. It is possible that *Oedembia* will be multispecific and prolific, as evidenced by the author's very extensive collection of specimens preserved in alcohol. The geographic range of these species may have increased as a result of colonial traffic.

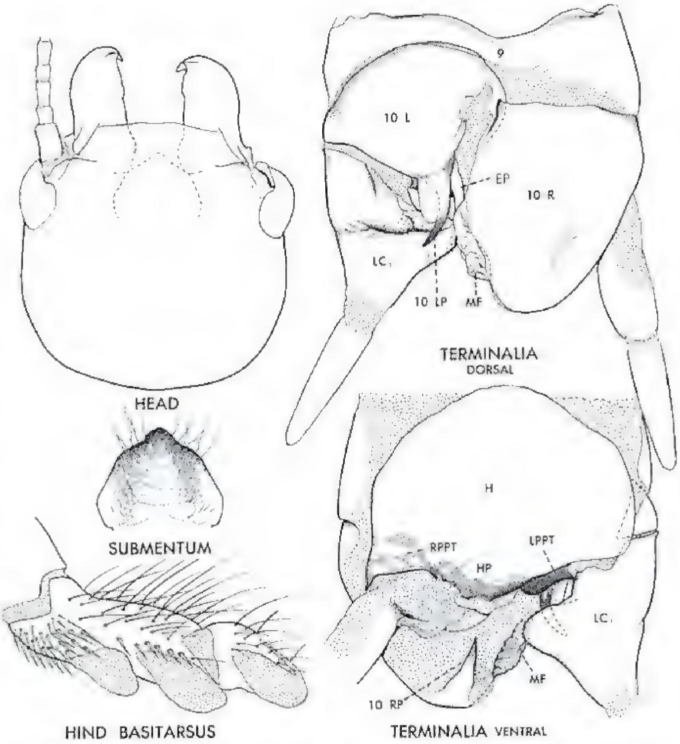

FIGURE 1. Important characters of holotype of *Oedembia dilatamenta* Ross. E.S.R (see page 599 for abbreviations).

***Oedembia burmana*** **Ross, sp. nov.**
Figure 2.

HOLOTYPE.— Male, on slide, CAS. Myanmar: 18 mi. SE of Mandalay, 400 ft. elev., matured in culture 29-XII-1978 (E.S. Ross).

DESCRIPTION.—Smaller than the larger, almost black *O. dilatamenta* with a paler prothorax. Submentum flatter; wings with less conspicuously white cross-veins; left tergal process not as abruptly broadened at base; basal segment of left cercus with transverse fold less prominent. Body length 12mm.

## Oligotomorpha, new infraorder
## Oligotomidae Enderlein, 1909

DISTRIBUTION.— Mediterranean, Middle East, Indian region, Southeastern Asia, and Australia.

DIAGNOSIS.— Males apterous or alate. Wings with MA unforked. Hind basitarsus with one or two papillae. Terminalia with medial flap (MF) separated from right hemitergite (10R) by an extensive membranous area which then projects caudad as though it is a process of the right hemitergite, but actually it appears to be MF rotated caudad. Basal segment of left cercus inwardly lobed or unlobed, never echinulated. Females without distinctive characters.

### Key to Genera of Southeastern Asian Oligotomidae (males)

1 Base of left cercus completely encircled by the basipodite (LCB) which projects mesad as a lobe . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Oligotoma*
– Base of left cercus with only an outer flange, which never completely encircles the cercus base and never is lobed . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 2
2 Basal segment of left cercus globular . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Bulbosembia*
– Basal segment of left cercus slender, never bulbous . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 3
3 Base of each mandible with a dorsal, thumb-like lobe . . . . . . . . . . . . . . . . . . . . . *Lobosembia*
– Mandibles without dorsal lobes . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 4
4 Size large, body length averaging 14 mm; often strongly bicolorous, basically blackish brown except for usually bright orange prothorax and bases of forelegs. Antennae usually distally white, setae usually longer than the bearing segment; Hind basitarsi usually with two ventral papillae. Terminalia with 10 LP usually broad, aedeagus usually sclerotic and broadened caudad . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Eosembia*
– Size medium, body length 5–10 mm. Body and legs brown throughout, prothorax only slightly paler. Antennae never white-tipped, medium brown throughout. Hind basitarsi never with two papillae. Terminalia with 10 LP slender, aedeagus not conspicuous . . . . . . . . *Aposthonia*

### *Eosembia* Ross, gen. nov.

TYPE SPECIES: *Eosembia nepalica*, Ross, sp. nov., present designation.

**NAME BASIS.**— *Eos* Greek = dawn, in reference to occurrence in lands of the "rising sun".

**DISTRIBUTION.**— Northeastern India and southeastern Asia.

**DISCUSSION.**— Only a few species have been described to date but, as a result of author's collecting, at least twenty five more await description. This contribution is limited to species occurring east of India with the exception of the new species, *Eosembia nepalica*, from lowlands of Nepal. It is selected as the type of the genus because it is so distinct that it should never be regarded as a congener of any species of the related, large, widespread genus *Aposthonia* Krauss. In some cases it is difficult to establish a sharp division between the two genera. Noteworthy *Eosembia* characters include in many of its species white distal antennal segments and two papillae on the hind basitarsi. Most males also have conspicuous sclerotization of the ejaculatory duct. In this character, and many others, there is inconsistency within the genus but none of these have a second hind basitarsal papilla.

Unlike smaller species of *Aposthonia*, those of *Eosembia* spin conspicuous galleries on the surface of tree trunks or road banks. In at least one species, freshly-spun silk has a violaceous sheen which later becomes white. Eggs are laid in a single-layered cluster covered with pulverized bark or feces. Broods are highly gregarious, develop in unison.

The largest concentration of *Eosembia* species occurs in evergreen forests of Assam (about 20 new species) and in Bangladesh (five new species). These, and previously-described species from India, will be treated in author's forthcoming general coverage of Embiidina of the Indian region.

During almost year-long travels in India (1961–62), the author encountered no *Eosembia* south of the Ganges, or in the damp evergreen forests of SW India. Perhaps species were unable to cross the central drier life zones of the subcontinent.

**DIAGNOSIS.**— Males large. In all but one east-of-India species (*spatha*), the thorax and forelegs are bright orange, other body parts are brownish black. West of Myanmar all species are entirely brownish black. Cranium small, slender, sides often caudally convergent. Eyes medium to small. Antennae very long, usually 28-segmented; distal segments abruptly white in some species and most segments bear very long, wavy, erect setae, as in the unrelated genus *Ptilocerembia*. Mandibles oligotomoid; submentum sclerotic but rather small, its sides and anterior margins strongly inflexed. Wings relatively large, darkly pigmented with violaceous luster; hyaline stripes very narrow, sharply defined; wing veins relatively well sclerotized, venation oligotomoid. Hind basitarsi elongate, plantar setae dense; a second papilla usually is small, acute, at times reduced to a minute, flat, circular spot, or very rarely it is absent. Abdominal terminalia basically oligotomoid with following features: Left tergal process (10 LP) usually slender, rather straight but in a few other species it is broad, spatulate, strongly depressed at its base, then curved upward distad; never distally divided into subprocesses. Hypandrium process (HP) often trough-like, occasionally twisted leftward exposing its surface to dorsal view. Ejaculatory duct (GON) usually extensively sclerotized, often a single filament extending its full length within HP; at times flattened and flared caudad, forming a flange between apices of 10 LP and HP. Left paraproct (LPPT) often extensively membranous on inner-basal side, but always with a sclerotic apical hook directed outward which sometimes is large and bulbous. Left cercus-basipodite (LCB) is a large, sclerotic flange fused to outer basal rim of the left cercus without trace of an inner lobe or ring. Basal segment of left cercus slender, varying from a simple cylindrical form to distally-expanded and lobed; other cercus segments normal, always sclerotized.

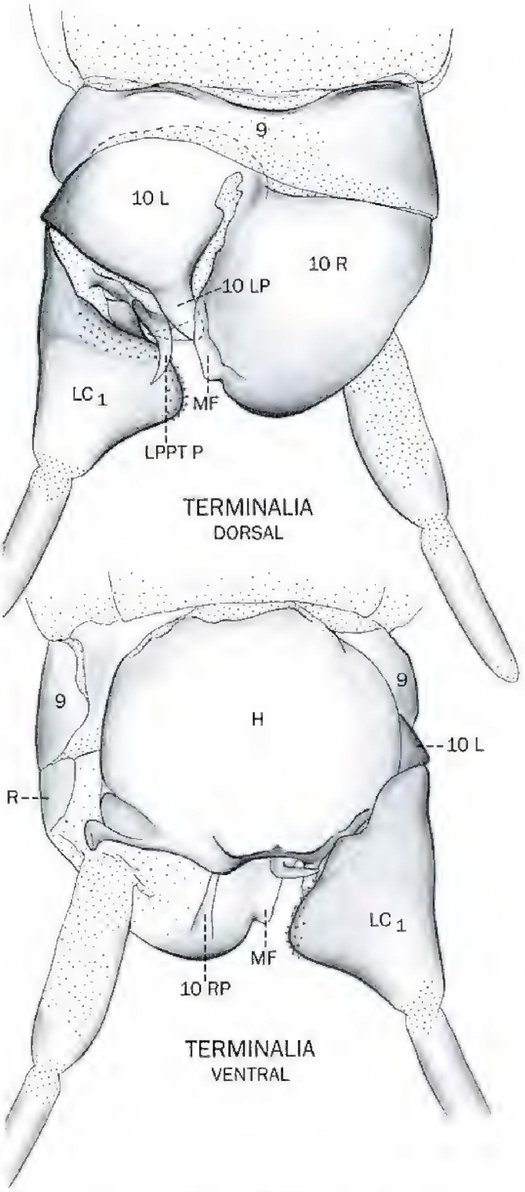

FIGURE 2. Important characters of holotype of *Oedembia burmana* Ross. J.C. (see page 599 for abbreviations).

FEMALES: Large, robust, richly pigmented. Often with distal antennal segments abruptly white. In some species the prothorax and certain leg segments are bright orange, but entirely dark in others. Intersegmental areas of thorax, coxae, and trochanters often whitish. Hind basitarsi often with two ventral papillae.

**COMPONENT SPECIES.**— More than twenty-five species are known to author. Most are new but not all will be described at this time. Certain previously-described species of "*Oligotoma*" will be assigned to the genus. Three species-groups are composed, as follows:

## *Nepalica* Group

*Eosembia nepalica* Ross, sp. nov. described below.
*Eosembia gravelyi* (Kapur and Kripalani), comb. nov.
*Oligotoma gravelyi* Kapur and Kripalani, 1957:127. TYPE: Zool. Survey of India, Calcutta. Type locality, Kalimpong, Darjeeling District, India, comb. nov.
*Eosembia montana* (Kapur and Kripalani), comb. nov.
*Oligotoma montana* Kapur and Kripalani, 1957:129. TYPE: Zool. Survey of India, Calcutta. Type locality, Pashok, Darjeeling District, India.
*Eosembia michaeli* (McLachlan), comb. nov.
*Oligotoma michaeli* McLachlan, 1877:383. TYPE: British Museum (Natural History). Male type was collected in a London orchid house. Source of the orchid was probably NE India or Myanmar. To date no complete specimen has been found. Kapur and Kripalani's specimen (1957:124) cannot conclusively be identified as *michaeli* due to incompleteness of their specimen.

### *Eosembia nepalica* Ross, sp. nov.

Figure 3.

**HOLOTYPE.**— Male, on slide, CAS. NEPAL: 2 miles E of Lamidanda, 1660 m, matured in culture (E.S.Ross).

**DESCRIPTION.**— Appearance: Large, slender, alate; blackish brown throughout, including antennal apices; all membranes dark. Color details (in alcohol): Cranium glossy black, lacking pattern, golden brown ventrally. Eyes lavender, with narrow, golden borders. Antennae 20-segmented; basally dark brown, blending distad to lighter brown, then tan to apex. Mandibles dark mahogany brown with piceous margins; submentum black, other mouthparts dark brown. Prothorax and its legs very dark mahogany brown with dark lavender membranes; pterothorax and its legs mahogany brown with intersegmental membranes dark creamy white tinged with purple. Wings similar in color to thorax; sclerotic areas of terminalia blackish brown except for the clear amber left process and the clouded amber apex of right process (10 RP or MF?) membranes of hypandrium lobe pinkish white; cerci very dark mahogany brown, extreme apices golden brown. Dimension (on slide): Body length 12.0; forewing length 7.5 mm, breadth 2.0 mm.

*Important anatomical characters*: As figured. They are: the caudally sclerotic and vaulted left hemitergite (10 L); the long, very slender, clear amber narrowly-based left process (10 LP); the basely-broad right process (10 RP or MF?) which is sclerotized half way up its inner side; the black sclerotization of the ejaculatory duct (GON); the very slender, scarcely lobed basal segment of left cercus.

**ALLOTYPE.**— Female, in alcohol, (CAS) from holotype's culture.

**DESCRIPTION.**— Appearance: Large, robust; dark brown except for white-tipped antennae, golden prothorax, and bases of forelegs. Color details: Cranium dark mahogany brown, blending to golden brown at extreme base and ventrally; eyes black; antennae dark brown to segment 17, segment 18 grayish white, segments 19 to 23 white. Submentum chestnut brown, other ventral mouthparts yellowish brown; palpi blending distad to medium brown. Cervical and prothoracic sclerites clear amber ventrally, dorsally more orange; membranes purplish, forelegs concolorous with pronotum except for mahogany brown tibiae and entire tarsi. Meso and metathoracic sclerites and legs dark, glossy chocolate brown except for tan trochanters and tibial bases. Abdominal sclerites similar with all membranes purplish white; sterna medium brown except for darker sides of sterna 8 and the entire 9, cerci concolorous with abdominal terga. Body length 17 mm. Without noteworthy anatomical characters except for the minute subapical second hind basitarsal papilla.

**Paratypes and parallotypes.**— Hundreds of adults from the type cultures; to be distributed in major entomological museums.

**Other specimens examined.**— A large cultured series from stock collected 10 mi NW of Hitaura, at 400 m in the Rapti Valley, Nepal.

**Discussion.**— This, one of the most western of known species of *Eosembia*, is readily distinguished by its very narrow, pale, left tergal process; broader right "process"; the larger sclerotization of ejaculatory duct; and narrower, more definite hook of left paraproct.

**Biology.**— The type colonies were found on the surface of road banks in a sal forest. Colonies were conspicuous white patches spun on soft granitic surfaces. Each labyrinth had a retreat leading into a rock crevice. Old silk is highly elastic and white, fresh silk is temporarily purple. In the same locality colonies also were found on and between planks of a small road culvert. Only females and third instar nymphs were found at the time of encounter in late November, 1961.

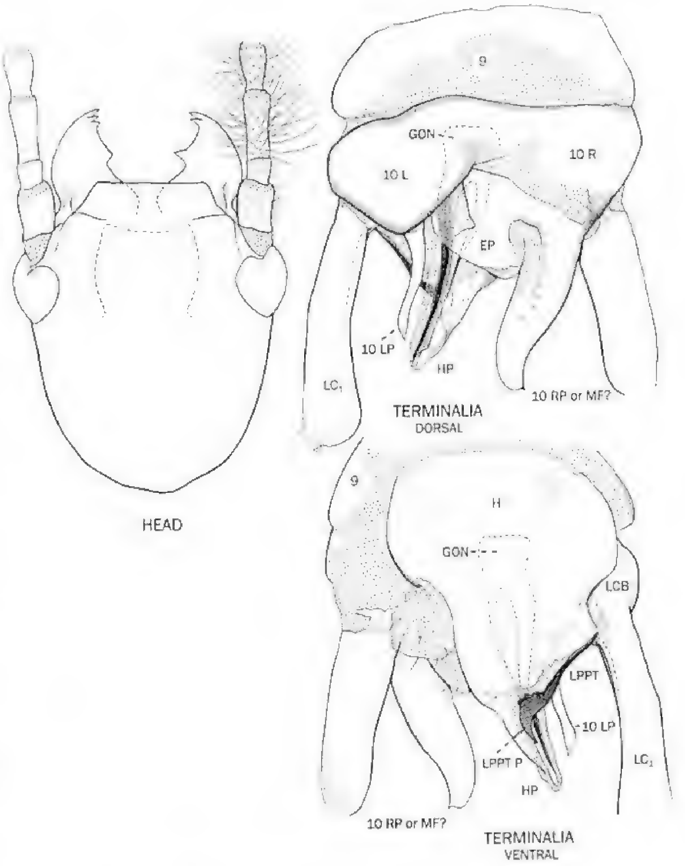

Figure 3. Important characters of holotype of *Eosembia nepalica* Ross. E.S.R. (see page 599 for abbreviations).

The Rapti Valley locality is much lower in altitude and largely forested with sal. Pines absent. Most galleries were found on tree trunks in deep shade, but most lacked embiids. Apparently they had been disturbed by some insectivore. Numerous tiny plokiophilid bugs were present. Only a few second or third instar embiid nymphs were present November 24, 1961, as well as a few egg masses. These were laid on bark surfaces in flat layers imbedded in a matrix of masticated bark or feces. Mature males appeared in cultures June to September, 1962.

## *Myanmara* Group

### *Eosembia myanmara* Ross, sp. nov.

Figures 4–5.

**Holotype.**— Male, on slide, CAS. Myanmar: Myamyo, 3530 ft elev. On bark of trees in the park. Matured in culture 23-I-79 (E.S. Ross).

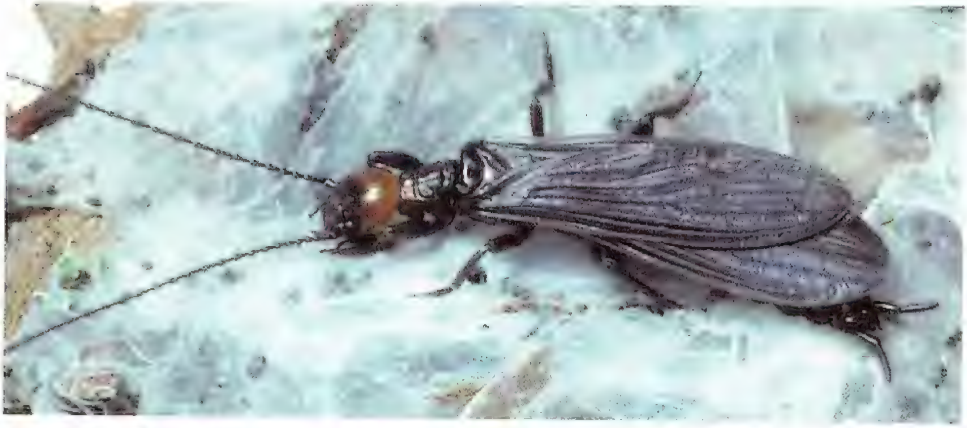

FIGURE 4. Live adult male of *Eosembia myanmara* Ross. E.S.R

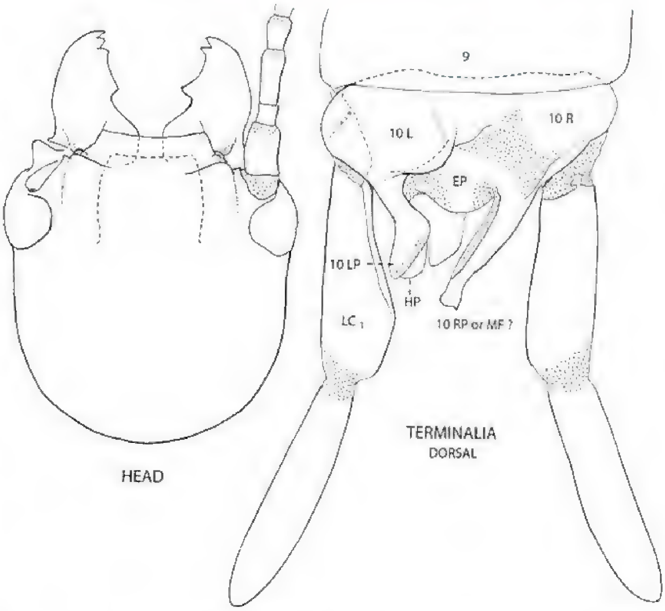

FIGURE 5. Important characters of holotype of *Eosembia myanmara* Ross. E.S.R. (see page 599 for abbreviations).

**DESCRIPTION.**— Very large, body length 20 mm, alate; purplish black except, in some variants, for golden posterior half of cranium. Color details (alive): Cranium golden behind eyes and ventrally, except for a faint brown pattern; anterior portion and clypeus piceous brown with ecdysial suture unusually clear. Eyes dark lavender. Antennal segments 1 and 2 piceous, all others grayish black to apex (28-segmented). Preclypeal and labral membranes lavender white, the former with two light brown sclerites; labrum piceous; mandibles glossy black; palpi dark brown; submentum sclerotic, orange tinged with piceous. Cervical sclerites yellow, some portion piceous brown; membranes purplish white. Pronotum basically yellow but margined, especially caudally with purplish dark brown. Pterothorax and its membranes various shades of purplish brown, except for scutae which basically are grayish cream. Legs mottled purplish brown without pale coxae. Abdomen concolorous with pterothorax except for the largely piceous brown terminalia and glossy black processes, apex of 10LP lavender white, process of LPPT and apex of 10RP or MF? translucent reddish amber. Dimensions (on slide): body length 20 mm; forewing length 10.5mm, breadth 3.5 mm.

*Important anatomical structures*: Cranium elongate, parallel-sided. Antennae 30-segmented, setae long, apicals not white. Hind basitarsi with a large, subapical papilla. Left hemitergite with a very dark brown, inflexed, caudal margin; its process constricted, then broadened, outwardly-slanted, thick and pale-edged; right hemitergite mostly membranous; epiproct, caudal margin and "process" (10 RP or MF?) very dark brown. HP tapered caudad; ejaculatory sclerite very thin. Paraproct process dark, but blunt. Basal segment of left cercus gradually expanded, but not lobed.

**ALLOTYPE.**— Female in alcohol (CAS) reared in holotype's culture.

**DESCRIPTION.**— Very large, body length 28 mm. Cranium mostly golden brown, frons and clypeus rugose, grading to piceous; antennae entirely dark brown except for five white distal segments. Prothorax golden with grayish white membranes; forelegs dark brown except for golden apices of femora. First acrotergite medium brown; all other body sclerites dark brown, with all intervening membranous areas white except those of thorax which are a little darker. All legs dark brown except for golden tibial "knee-joints", hind basitarsi with two, prominent papillae. Cerci entirely medium brown.

**DISCUSSION.**— This species is very common on tree trunks around the town's big artificial lake in the park. The clean silk galleries are large and conspicuous, but author didn't find any during his very short visit into an adjacent patch of native forest. Because of extensive past colonial traffic, the species may have been introduced from elsewhere. Author reared a large number of paratypes in several cultures. These will be distributed in major museums.

## *Auripecta* Group

### *Eosembia auripecta* Ross, sp. nov.

Figures 6–7.

**HOLOTYPE.**— Male, on slide, CAS. THAILAND: 13 mi SE Lee (Li), 500 m, matured in culture 7-IV-1963 (E.S. Ross).

**NAME BASIS.**— The golden pterothorax of males.

**HOLOTYPE.**— Male very large, alate; blackish brown, most of thorax and forelegs bright orange; antennae white-tipped. Color details (in alcohol): Cranium blackish brown dorsally, lacking pattern, ventral surface clear amber. Eyes dark lavender, narrowly rimmed with gold. Antennae 30-segmented, almost as dark as cranium except for two distal white segments tinged with tan. Mouthparts concolorous with cranium but submentum is partially dark amber. Cervical and prothoracic sclerites bright gold; all membranes dark creamy white but not strongly contrasting with sclerites. Foretarsi and tibiae concolorous with cranium, forelegs otherwise bright gold, paler than pronotum. Pleura and sterna of mesothorax golden to chestnut brown, poststernum brown; comparable sclerites of metathorax largely mahogany brown; mesothoracic tarsi and tibiae dark mahogany brown, legs otherwise chestnut brown; hind legs dark mahogany brown with membranes and tarsal papilla lavender white. Wings very dark brown with bright, violaceous iridescence, hyaline stripes very narrow, sharply defined; bordering lines of RBS bright rusty red. Abdominal sclerites, including most of terminalia and cerci, blackish brown; left tergal process (10 LP) becoming bright straw yellow distad, narrowly rimmed with reddish amber; membranes of hypandrium lobe (HP) pinkish white. Dimensions (on slide): body length 16.5 mm, forewing length 9.0 mm, breadth 2.2 mm.

*Important anatomical characters*: As figured and as follows: The broad, spatulate left tergal process (10 LP) with a sharp obtuse outer-apical angle; the acuminate, slender, hooked apex of the right process (10 RP or MF?); the slender, distally-flared, sclerotic ejaculatory duct (GO); the broad-based, caudally-arcuated, left paraproct's hook (LPPT P); and the long, slender, slightly lobed basal segment of the left cercus.

**ALLOTYPE.**— Female, in alcohol, CAS, from holotype's culture.

**DESCRIPTION.**— Large, robust; blackish brown except for the following: golden prothorax, creamy white band between meso and metathorax, largely orange fore and mid legs, and white-tipped antennae. Color details: Cranium dark chocolate brown with mahogany ecdysial suture and caudally suffused gular area which is amber yellow; preclypeal membrane whitish. Eyes almost concolorous with cranium. Antennae 28-segmented, uniformly dark chocolate brown except for six white distal segments. Cervical and prothoracic sclerites including acrotergite (but not the poststernum) orange; associated membranes grayish cream; forelegs concolorous with pronotum except for dark mahogany brown basitarsi. Meso and metathoracic sclerites very dark mahogany brown except for clear, yellowish acrotergite and prescutum which, in combination with creamy white internal fat, creates a pale band between the thoracic somites; mid legs entirely orange, hind legs entirely dark mahogany brown except for a golden femorotibial joint. Abdomen and cerci concolorous with metathoracic scutum, dorso-pleural and intersegmental membranes contrastingly white; sternites and paraprocts golden brown except for dark areas of sterna 8 and 9. Body length 22 mm. Without noteworthy anatomical characters except for the conspicuous, medial hind basitarsal papilla; and the microsetose first valvifer with lateral sclerotization.

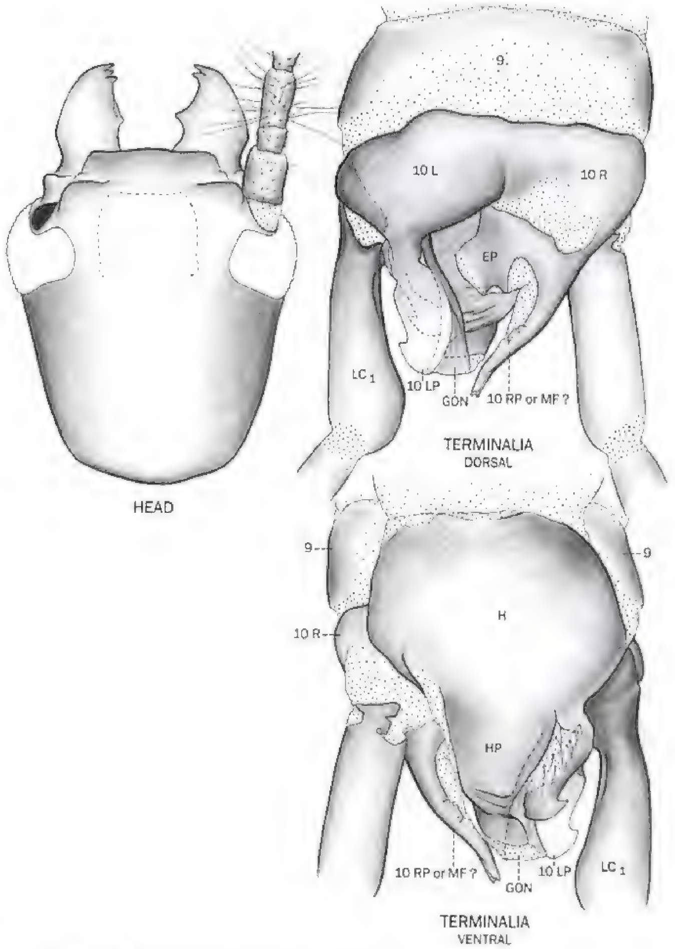

FIGURE 6. Important characters of holotype of *Eosembia auripecta* Ross. J.C. (see page 599 for abbreviations).

PARATYPES AND PARALLOTYPES.— Hundreds of adults reared in the type cultures to be distributed in major entomological museums.

OTHER SPECIMENS EXAMINED.— Large series reared from cultures stocked from the following Thailand localities: Chiang Mai's Doi Suthep; 10 mi N of Saraburi; Yan Hee Dam; Khao-Yai National Park; Banpe (13 mi SE of Rayong); hills 20 mi SE of Chantaburi; and Prachuap. It is possible that close study will show that several races or species are involved in these extensive series. Males of populations differ from that of the type in having the distal four antennal segments white as well as in other coloration characters.

DISCUSSION.— Closely related new species or races have been collected in Laos, Vietnam, and peninsular Thailand. It is probable that a difficult complex of *E. auripecta* relatives occurs throughout southeastern Asia, including *Oligotoma hainanensis* Lu from Hainan Island, China. For the

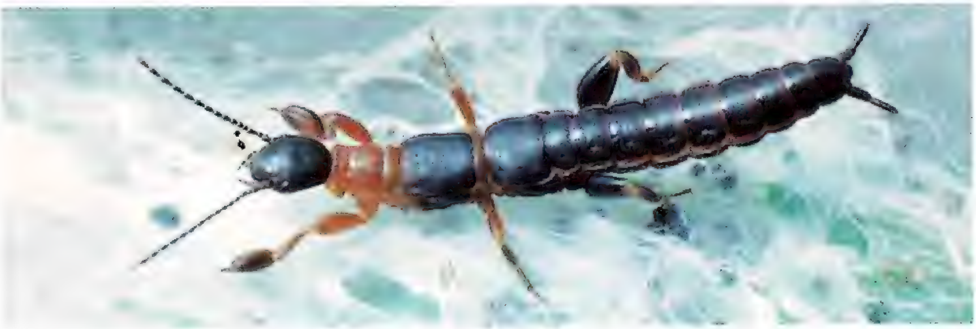

FIGURE 7. Live adult female of *Eosembia auripecta* Ross. E.S.R.

present, until related species are described, *E. auripecta* can be recognized by its terminalia characters and coloration of both sexes. Unrelated species, such as *E. aequicercata* (described below), have similar size and coloration.

**BIOLOGY.**— *Eosembia auripecta* principally colonizes bark of trees and logs in evergreen tropical forests, or in secondary growth; labyrinths of the highly gregarious broods may cover extensive bark surfaces. The silk isn't sprinkled with pulverized bark or feces, as in *Ptilocerembia* and some other genera, colonies of which may occur in the same habitats. In seasonally-dry forest with deciduous hardwoods, *E. auripecta* may gain security in bark crevices, as well as near the bases of saplings and stones. During author's field encounters (mid-July), mating had recently occurred; adult males apparently had been present a few weeks earlier but had since died. Adult females were present with their egg masses and early instar young. The following year adults began maturing in cultures as early as February, but peak maturity period was in April through June.

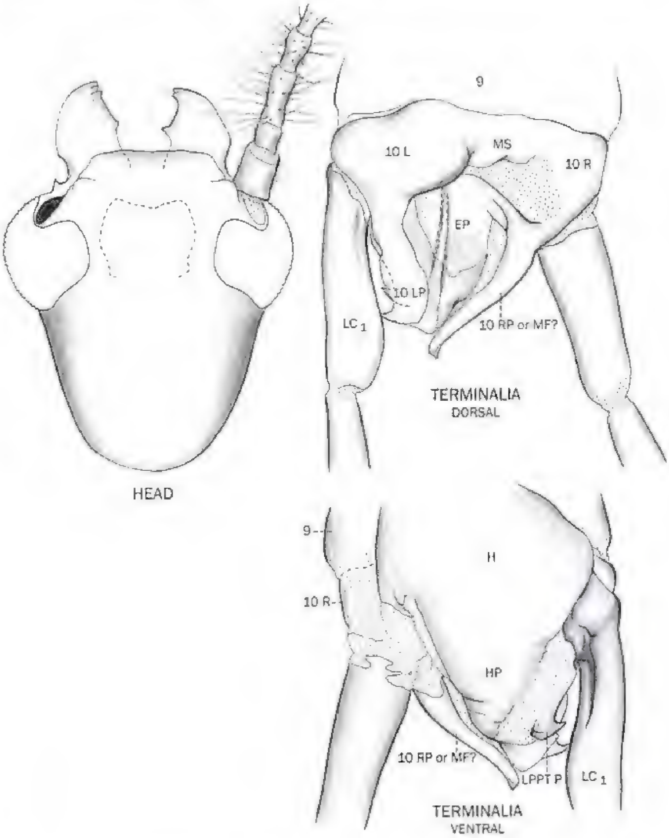

FIGURE 8. Important characters of holotype of *Eosembia laotica* Ross. J.C. (see page 599 for abbreviations).

### *Eosembia laotica* Ross, sp. nov.

Figure 8.

**HOLOTYPE.**— Male, on slide, CAS. LAOS: 30 km SE of Pakse, matured in culture II-1971 (E.S. Ross).

**DESCRIPTION.**— Appearance very large, body length 16 mm; light brown, fore body and its legs tan. Cranium narrowly convergent caudad; eyes large protruded, interspace equal to an eye-width. Antennae 31-segmented, distal five white; setae long. Hind basitarsi densely setose, a second papilla not evident. Left tergal process of terminalia rather broad but narrower than that of *E. auripecta*, an otherwise similar species.

FEMALES: without significant features.

**PARATYPES AND PARALLOTYPES.**— Numerous topotypes reared from colonies on bark of very large trees; to be deposited in major museums.

**DISCUSSION.**— *Laotica* is very similar to *E. auripecta* of Thailand but differs in cranial and eye form, fewer white distal antennal segments, narrower 10 LP, and less vivid coloration. Specimens from 16 km S of Tha Teng, Bolovens Plateau, Laos, I-16-1961 (R.E. Leech) are almost identical to *E. auripecta*.

### *Eosembia malaya* Ross, sp. nov.

Figures 9–10.

**HOLOTYPE:** Male, on slide, CAS. MALAYA: Jor Camp, matured in culture 23-VII-1963 (E.S. Ross).

**DESCRIPTION.**— HOLOTYPE: Male, Cranium very dark brown anteriorly, blending caudad to yellow brown; sides straight, convergent caudad. Antennae 32-segmented, uniformly light brown except for thin-walled, abruptly-white, smaller, five distals; setae long, wavy. Mandibles dark mahogany, deeply excised, proxadental cusp of right mandible especially large, acute. Submentum sclerotic, dark mahogany; pronotum light yellow, pleura and sterna light brown, surrounding membranous areas pale yellow. All legs light brown. Abdominal terga and sterna light brown, membranous areas pale tan. Hind basitarsi with a medial

FIGURE 9. Galleries of *Eosembia malaya* Ross. E.S.R.

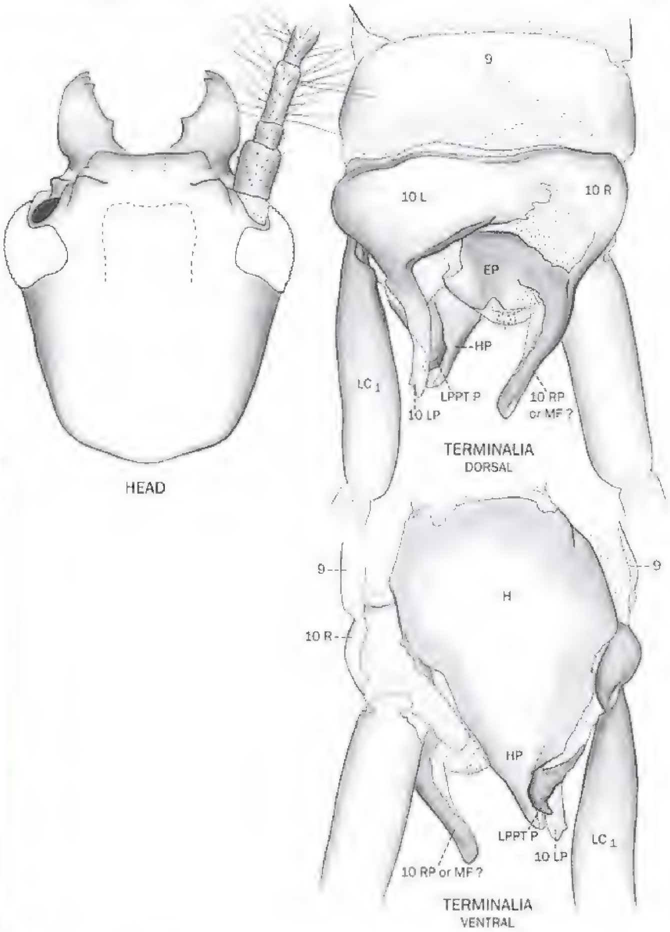

FIGURE 10. Important characters of holotype of *Eosembia malaya* Ross. J.C. (see page 599 for abbreviations).

papilla. Sclerotic surfaces of terminalia glossy medium brown, membranous surfaces white; cerci uniformly medium brown, joints grayish white. Structure of processes as figured. Dimensions (on slide): body length 17 mm; forewing length 11 mm, breadth 3 mm.

ALLOTYPE: Female, golden with faint cranial pattern; mouthparts pale tan. Antennae 24-segmented, distal segments white. Body almost entirely pale yellow. Pronotum and abdominal surfaces clouded with light brown. All legs pale yellow. Abdominal pleura creamy white; cerci entirely very pale yellow. Hind basitarsi with a medial papilla. Body length 18 mm.

PARATYPES AND PARALLOTYPES.— Numerous specimens from holotype's culture; CAS to be deposited in major museums.

DISCUSSION.— This species is unique in its extensively pale yellow coloration. Large colonies were present on several large tree trunks in a semi-cleared, once-forested area.

### *Thoracica* Group

### *Eosembia thoracica* (Davis), comb. nov.

Figure 11.

*Oligotoma thoracica* Davis, 1940b:370. Cotypes: Three males, Museo Storia Nat. Genoa. Data: Burma, "Carin Chebã".

LECTOTYPE.— Present designation. One of the above cotypes was transferred to CAS. These cotypes were the basis for *Oligotoma collaris* Navás, 1927: 388, which Navás had misidentified as *Haploembia collaris* Navás 1923:14, of the Congo. On this basis Navás transferred *collaris* to the genus *Oligotoma*. Davis, 1940b, recognizing this error, justifiably proposed a new name for the Burmese males. Author has studied all specimens involved in these actions and concluded that *Oligotoma collaris* Navás, 1923, represents a valid species of the African genus *Dihybocercus* Enderlein (Embiidae).

The Lectotype, now designated, selected by author from one of the Burmese Cotypes, is treated, as follows: Lectotype, (present designation.) –Alate male, on slide, deposited in Museo Civico di Storia Naturale, Genoa. Type labels.— "Carin Chebã 900-1100 m. L. Fea. VI. 88," "*Oligotoma collaris* Nav. P Navás S. J. det." (green paper, Navás' hand), "*Oligotoma thoracica* Davis cotype" (Davis' hand).

LOCALITY INTERPRETATION.— This locality appears to be in the Thandaung Reserved Forest, Karen Hills, Toungoo Distr. S. Myanmar, 19°04′N, 96°41′E; 9010-1100 N. Snelling (1988 *Ent News* 99:12) reported that this locality is at 24°59′N, 96°52′E, a mountainous area about 105 km NW of Bhano, Kachin State, Burma.

CONDITION OF LECTOTYPE.— Originally carded, wings spread; head, mid-legs, and terminalia were mounted in balsam by Davis, 1939. Entire specimen has since been combined by author on one slide in balsam. Condition good with all appendages complete except distal antennal segments.

DESCRIPTION.— Very large, broad-winged; antennae exceptionally long, hirsute; body shining blackish brown except for an orange prothorax including its coxae, trochanters, and femora. Cranium piceous black lacking pattern, gular surface golden brown. Antennae concolorous with cranium, becoming slightly more brownish distad, distal segments never white. Submentum and other mouthparts golden blending to reddish brown. Prothorax, including first spinasternum, orange; forecoxae, trochanters, and femora golden brown (possibly orange in life); tibiae dark brown, tarsi piceous. Remainder of thorax piceous brown, shining, sclerotized areas with a violaceous luster; midcoxae, trochanters, tibiae, and tarsi medium brown, femora golden brown; hind legs entirely dark brown. Abdomen entirely dark brown with faint violaceous luster. Dimensions (on slide): body length 19.5 mm; forewing length 10.25 mm, breadth 2.4 mm.

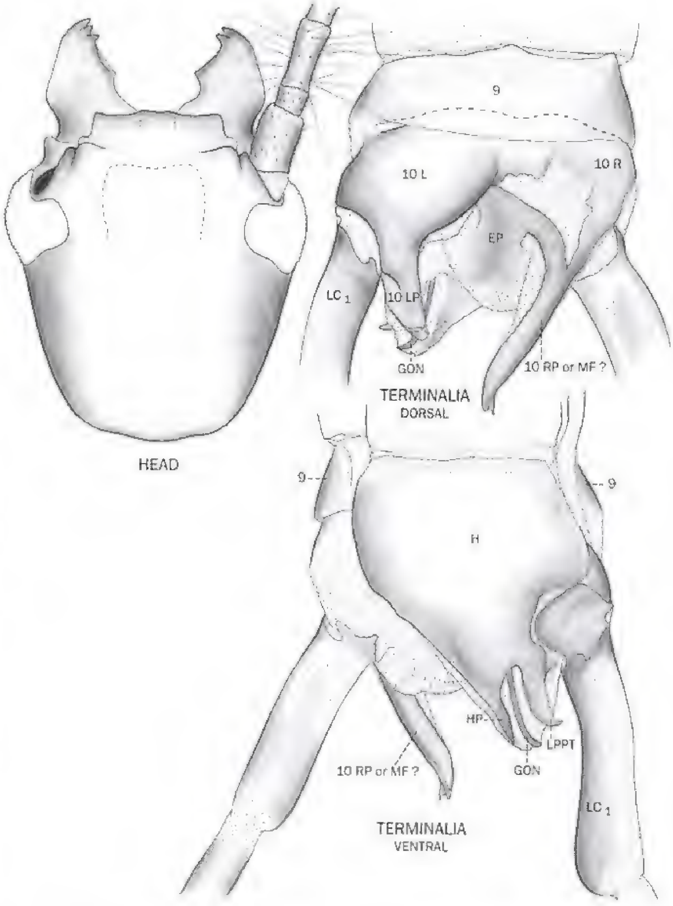

FIGURE 11. Important characters of lectotype of *Eosembia thoracica* (Davis). J.C. (see page 599 for abbreviations).

*Important anatomical characters*: Cranium narrow, oval, sides convergent behind eyes, caudal margin narrowly rounded; surface between eyes foveate and transversely rugose. Eyes small, globose. Antennae exceptionally long; basal segments stout, flagellars elongate; setae very long, erect, wavy. Mandibles short, oligotomoid. Submentum quadrate, sclerotization average; sides broadly arcuate, anterior angles rounded, apical margin shallowly emarginated. Wings with oligotomoid venation; "granular" borders of RA dark purple: pigment bands very dark, broad; hyaline stripes narrow, sharply defined; veins MA, MP, and CuA, represented only by rows of setae; cross-veins present between C and RA and RA and RP. Hind basitarsus elongate; plantar setae uniform in size and located along entire outer ventral surface, large setae irregular and sparse on inner surface; a second smaller papilla is present subapically. Terminalia with left hemitergite vaulted, its outer, inner, and caudal margins heavily sclerotized; process (10 LP) short broad, parallel-sided, apex obliquely-truncate, outer margin thin, pale amber. Right hemitergite largely membranous, sclerotic along outer margin only; process (10 RP or MF?) greatly elongated, extensively membranous on inner, apex with a small outer hook. Hypandrium process (HP) narrowly sclerotized, its margin and apex membranous, densely microspiculate (the spiculations not sharp, but disc-like); an internal, slender, rod-like sclerite parallels the narrow sclerotization of HP and probably sheaths the aedeagus. Left paraproct produced caudad as a slender sclerite bearing a large, outwardly-directed hook. Basal segment of left cercus greatly elongated, slightly constricted medially then expanded at inner apes; inner margin sclerotic, outer margin medially submembranous; outer ventral flange (LCB?) extensive, notched into side of hypandrium. Basal segments of right cercus evenly sclerotized and cylindrical.

**REMARKS.**— A second "Cotype", Genoa museum, is of little value, because its terminalia are extensively damaged. In other characters, including color, it agrees with the lectotype. Author found a third specimen in the Navás Collection in Zaragoza, Spain. *Thoracica* is not closely related to any other known species of its genus. Additional collecting in Myanmar will probably yield related species.

In 1979, author encountered a large colony of embiids on a tree trunk in western Shan State, Myanmar, at Sintai, 1000 ft, 30 mi E of Meiktila. Cultures produced hundreds of specimens (CAS).

The specimens appear to represent *E. thoracica*, differing only in minor terminalia structures, such as the shorter, broader of outwardly-slanted 10 LP. The cultures also provide an opportunity to briefly describe coloration of the very large females (body length 24 mm), as follows:

Antennae brown, except five whitish tan distal segments; prothorax, its legs, cervical sclerites, and first spinasternum yellowish. Remainder of thorax, cerci, and all body sclerites very dark brown; most intersclerotital membranes white, lateral membranous areas of thorax lavender, including joint membranes.

## *Aequicercata* Group

### *Eosembia aequicercata* Ross, sp. nov.

Figure 12.

HOLOTYPE.— Male, on slide (CAS). THAILAND: 13 mi SE of Lee (Li), 600 m, matured in culture 5-IV-1963 (E.S. Ross).

NAME BASIS.— Reference to the almost equal left and right cerci of males.

DESCRIPTION.— Appearance very large, alate, blackish brown except for bright yellow prothorax. Antennal apices tan, never white. Color details (in alcohol): Cranium glossy blackish brown, lacking pattern; gula and margins of occipital foramen amber yellow. Eyes dark purple but paler than cranium. Antennae 25-segmented, the basal one brownish mahogany, segment 2 lighter, 3-5 pale yellow, others blending to blackish brown, extreme apex blending to tan. Cervical and prothoracic sclerites golden; poststernum blending to brown; membranes basically creamy white tinged with pink. Forelegs mahogany brown, trochanters and coxae golden. Pterothorax and its legs dark mahogany brown with dark purple membranes. Abdomen matching the color of pterothorax except for more blackish cerci and terminalia. Apex of left process dark amber. Dimensions (on slide): body length 16.5 mm; forewing length 9.0 mm, breadth 2.2 mm.

*Important anatomical characters*: As figured. Antennal segments rather short; setae shorter than segment-width, not erect or wavy. Cranium convex, elongate-oval; eyes small, located forward. Mid hind basitarsal papilla very close to the distal one. Left tergal process (10 LP) long, narrow, gradually arced leftward, evenly tapered to apex. Right process (10 RP or MF?) parallel-sided except for an abruptly tapered apex. Ejaculatory duct lacking sclerotization. Left paraproct (LPPT) a broad plate fused at base to hypandrium (H), bearing a small, barb-like apical point directed leftward. Basal segment of left cercus constricted, sclerotic at base, gradually expanded distad but not abruptly lobed, almost equal in form to basal segment of right cercus; distal segments of cerci exceptionally stout, almost as thick as basal segments.

ALLOTYPE.— Female, in alcohol, CAS. From holotype's culture.

DESCRIPTION.— Very large, robust; blackish brown except for orange prothorax and basal segments of forelegs and white-tipped antennae. Color details: Cranium blackish, lacking pattern, becoming golden ventrally. Antennae mostly concolorous with cranium, sub-basal segments 2 to 5 chestnut brown, distal segments 24 to 27 white. Cervical and prothoracic sclerites bright orange (including most of poststernum), surrounding membranes pinkish cream. Meso and metathoracic sclerites varied shades of dark mahogany brown; surrounding membranes dark purple, those between somites not forming a pale band. Forelegs concolorous with prothorax except for mahogany brown tibiae and tarsi; mid and hind legs concolorous with respective thoracic somites except for yellowish femorotibial joint. Abdominal coloration similar to that of meso and metathorax; sclerotic areas of sternites 8 and 9 not much darker than others. Body length 19 mm.

*Important anatomical characters*: Mid hind basitarsal papilla, almost as large as the distal, are located just distad of midsegment. First valvifer weakly sclerotized and laterally setose, but not medially; aperture of accessory gland without special surrounding structure.

Paratypes and parallotypes.— Hundreds of adults reared in the type culture; will be distributed in major entomological museums.

Discussion.— *Eosembia. aequicercata* is most closely related to *E. varians* (Navás) of SW China, including Hong Kong. Principal differences are in coloration, mandibular form, and the more slender tergal processes of *E. aequicercata*. Two other new species, from Vietnam and northern Thailand, have more slender males but have in common an absence of sclerotization of the ejaculatory duct. These four species form a distinct species-group characterized by the last mentioned character.

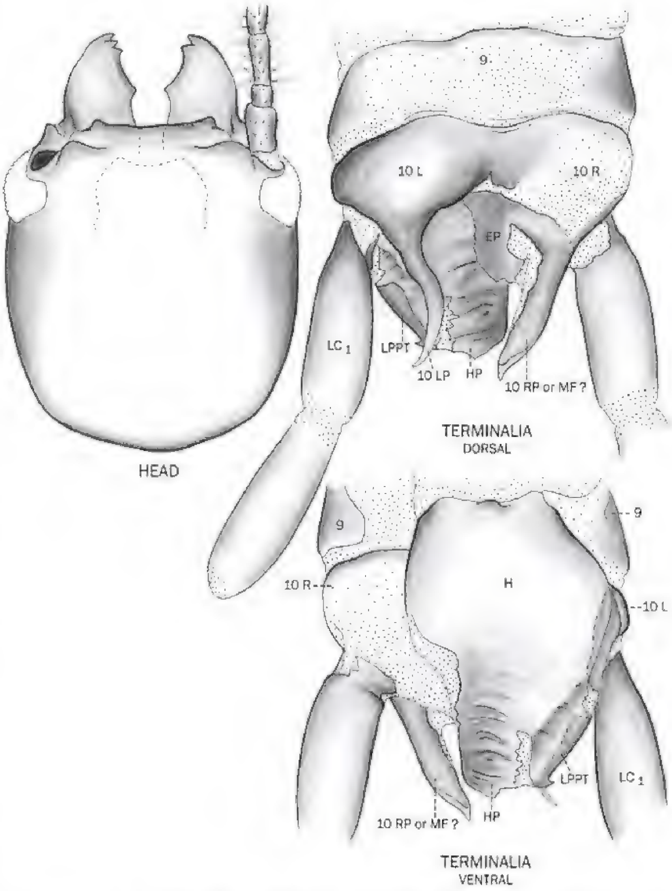

Figure 12. Important characters of holotype of *Eosembia aequicercata* Ross. J.C. (see page 599 for abbreviations).

Biology.— The type locality is a rocky ridge in low hills covered with open hardwood forest subject to seasonal drought and fires. Stock for cultures comprising only adult females and egg masses was collected 19-VII-1962 soon after first rains of the wet season. Colonies occur in dry bark crevices, on the sides of stones, and on bases of small saplings. *Auripecta* occurs in the same habitats but its females are distinguished, among other characters, by their yellowish or orange midlegs and a pale meso-metathoracic intersomital band.

Progeny began maturing during February of 1963 and continued through May with peak maturation during April. This periodicity was repeated in 1964 broods.

### *Eosembia varians* (Navás), comb. nov.

*Oligotoma varians* Navás, 1922:32. Davis 1940b:376.
*Aposthonia varians* (Ross), 1978:3.

Holotype.— Alate male, on slide, Mus. Nat. d' Hist. Nat. Paris.

**Description.**— Males large, body length 14 mm; alate, entirely black. Cranium, and all sclerotic portions of body and appendages black; all antennal segments black, distally becoming tan but never white; setae not long and wavy. Mandibles and submentum reddish mahogany. All abdominal portions, including terminalia, mahogany; 10 LP broad, tapered and arcuated caudad; cerci dark tan, the left expanded but not abruptly lobed. Second papilla of basitarsi not evident, except as a small, flat, less-sclerotic spot.

*Female Hong Kong specimen*: Large, bicolorous. Cranium very dark brown, alutaceus. Antennal segments almost black, five distals small, white. Prothorax orange, slightly mottled with tan; forecoxae, trochanters, and femora orange. Foretibiae medium brown, fore-tarsi, metathorax, and abdomen concolorous with cranium; membranous portions of thorax lavender. Cerci dark brown. Body length average 16 mm.

**Discussion.**— This is a widespread, endemic species in SW China, closely related to *O. aequicercata* but differing in minor details, such as antennal coloration. Conspecific males have been collected in several localities, as reported in author's 1978 paper. The largest population was encountered on deforested heights (now grasslands) of Tai Mo Shan, above New Territories, Hong Kong. Cultured specimens served as a basis for the above redescriptions.

## *Spatha* Group

### *Eosembia spatha* Ross, sp. nov.

Figure 13.

**Holotype.**— Male, on slide, CAS. Myanmar: Taung-gyi (Taunggy), 4712 ft elev., matured in culture 20-III-1979 (E.S. Ross).

**Name basis.**— Gr. *spathe* = broad sword, refers to broad left tergal process.

**Description.**— Moderately large, body length 12 mm, alate; entirely black, including antennal apices. Color details (alive): Cranium jet black, surface alutaceous, but glossy. Eyes purplish black. Antennae entirely black, excepting slightly paler distal segments, membranes rusty red. Preclypeal and labral membranes rusty red; all sclerotized portions of mouthparts glossy black, membranes pinkish. All thoracic sclerites and legs glossy jet black, associated membranes pink with a dark, rusty red, subcutaneous tinge. Wing bands smoky black, hyaline stripes narrow, sharply defined; costal and radial borders bright rusty red. Abdominal terga 1 to 9 dark brown, membranes similar to those of thorax. Terminalia sclerites glossy jet black except for left tergal process (10 LP) and

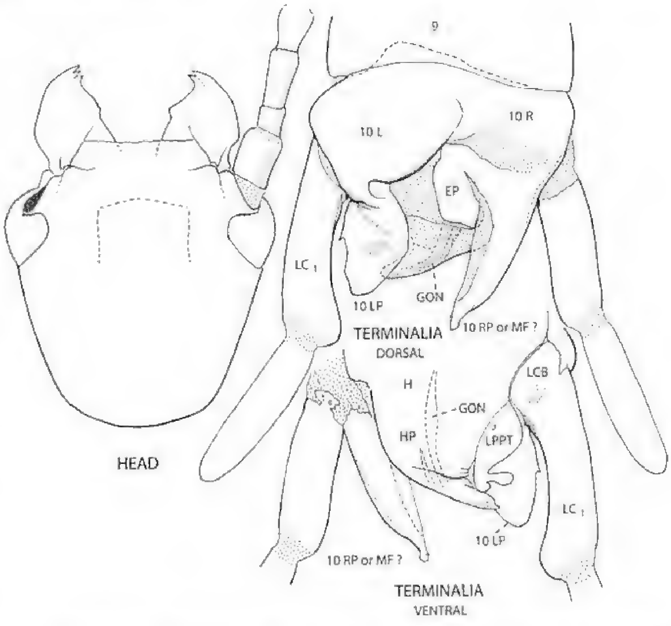

Figure 13. Important characters of holotype of *Eosembia spatha* Ross. E.S.R. (see page 599 for abbreviations).

left paraproct process (LPPT-P) which are translucent mahogany brown; cerci mostly blackish with dark purple membranes.

*Anatomical characters*: Antennal setae very long, gradually shorter distad. Hind basitarsi with a small, almost terminal papilla. Left process of terminalia very broad, scoop-like, inner side evenly arcuate, outer side straight with a small, acute basal projection; hypandrium lobe (HP) sclerotic, short, broadly arcuated toward right and dorsad; left paraproct not fused to HP, sclerotic and bearing a prominent, thumb-like lobe adeagus sclerite arcuated basad beneath HP. Basal segment of left cercus incurved but not lobed.

**Discussion.**— This is a very distinctive species that might later be assigned to a separate new genus. Only a few males (CAS) were reared from stock collected in bark of small trees in front of the district headquarters building. Time didn't permit more extensive collecting.

## *Aposthonia* Krauss

Figure 14.

*Aposthonia* Krauss, 1911: 48.— Enderlein, 1912:100 (as syn. of *Oligotoma* Westwood).— Davis, 1936:233; 1940b:363 (as syn. of *Oligotoma*).— Ross, 1956b:316 (as valid genus); 1963:135.
*Oligotoma* (*Aposthonia*) Krauss, Ross, 1955:2.

**Type species.**— *Aposthonia vosseleri* Krauss, 1911: 48 (= *Oligotoma borneënsis* Hagen), original designation.

**Distribution.**— Tropical Asia, north to southern Japan; Indonesia, Melanesia, and throughout Australia. A few species spread by man to Oceania, New Caledonia, Madagascar, and east African coasts. Absent in Afrotropical region and the Americas.

**Diagnosis.**— Males: Very small to moderately large, body (length 5–17 mm); apterous or alate; coloration diverse, never with antennal apices white, or body and legs brightly pigmented as in many *Eosembia*. Hind basitarsi never with more than one papilla. Terminalia basically as in *Eosembia* but never with prominent internal phallic sclerotization. Distinguished from *Oligotoma* by absence of mesal lobing of the left cercus-basipodite and simplicity of the left paraproct process. Females

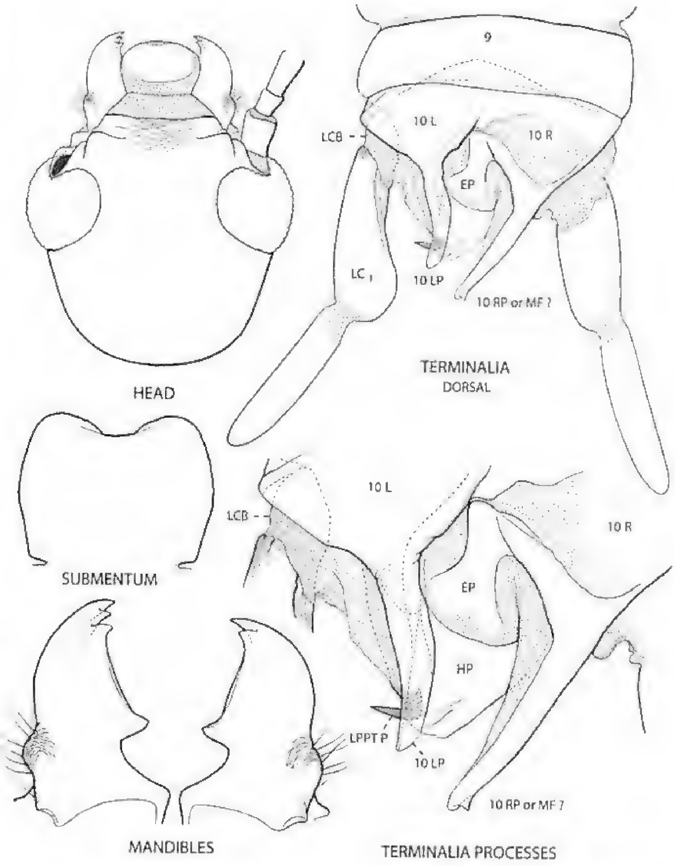

Figure 14. Important characters of holotype of *Aposthonia borneënsis* (Hagen). E.S.R. (see page 599 for abbreviations).

readily separated from those of *Eosembia* by absence of white apical segments of the antennae and lack of a second hind basitarsal papilla.

**Discussion.**— There has been hesitation to accept *Aposthonia* as a valid genus. However, a survey of the many known and new species in author's collection reveals a wide range of species-groups, some of which eventually may prove to represent distinct genera or subgenera. It is author's regrettable practice to use *Aposthonia* as a "catch-all" for oligotomoid species-groups insufficiently distinct to be treated as genera.

Potentially *Aposthonia* is the largest genus of the order, often with monotonously-similar species distinguished by combinations of minor differences in size, coloration, and not, as a rule, by striking male terminalia characters. Only the type genus will be treated at this time. Many of the scores of other species will be covered in Part II of this study, as well as in future publications.

### *Oligotoma* Latreille

India has many endemic species of this important genus, three of which have widely dispersed in commerce. Because their adult males are attracted to lights, they are most frequently collected. One other species *Oligotoma greeniana* Enderlein, has spread less widely. "Weed species" are frequently collected within the regional scope of this paper but only the two described below are endemic in Myanmar.

The east Asian "weed species" of *Oligotoma* are: *O. humbertiana* (Saussure), males characterized by a conspicuous spine near the outer apex of 10 RP or MF?; *O. saundersii* (Westwood), males with a horizontal sickle-shaped ventral process of LLPT and a broad 10 LP; and *O. greeniana* Enderlein with a broad-based, apically-twisted, tapered 10 LP. Of course, there are many other characters peculiar to these species. The Myanmar endemic new species are as follows:

### *Oligotoma burmana* Ross, sp. nov.

Figure 15.

**Holotype.**— Male, on slide CAS. Myanmar: Kalaw, Shan State, 4292 ft elev., matured in culture 29-I-1979 (E.S. Ross).

**Description.**— Very dark brown throughout, including all antennal segments; mandibles reddish dark brown. Alate, venation oligotomoid. Legs unicolorous dark brown except for yellowish extreme bases of hind tibiae, hind basitarsus without a second papilla. Terminalia basically oligotomoid; 10 LP rather short, broad, apex golden, rounded partly cleft and projected into inner side of the LCB process; hypandrium process (HP) short, dark brown dorsally and ventrally, sclerotic, apex rounded; left paraproct (LPPT) fused to hypandrium (H), its caudal edge sclerotic, narrowly and evenly arcuated; left cercus-basipodite (LCB) large, dorsally lobed, with a ventral sclerotic, thumb like, subventral lobe projected mesad; basal segment of left cercus unlobed, its outer side membranous. Body length 10 mm; forewing length 0.6 mm breadth 1.3 mm.

**Allotype.**— Female from holotype's culture. Paratypes and parallotypes. Numerous specimens from holotype's culture, CAS, to be distributed in major institutions.

**Other specimens.**— Author collected another series 18 mi SE of Mandalay, 400 ft elev. (a much lower altitude than that of the type series, 4292 ft elev., in a pine forest). In view of the altitudinal differences and minor terminalia details, the series may represent a distinct species.

### *Oligotoma ubicki* Ross, sp. nov.

Figure 15.

**Holotype.**— Male, on slide, CAS. Myanmar: Magway Division, Showe Settaw Wildlife Reservation, el. 137 m, in deciduous forest, at night, 29-IX-2003 (D. Ubick).

**Description.**— Light brown, alate; body length 8 mm; forewing length 6 mm, breadth 1.3 mm. With general characteristics of *O. burmana* but smaller and paler. Terminalia with its base and right side sclerotic and dark piceous, outer side less sclerotic and pale; beneath the base is a peculiar, interior thumb-like lobe; left cercus lobe (LCB) broadened distad, covering a pale module . Hypandrium (HP) lobe dark, short, rounded. Left paraproct (LPPT) amber-colored with large sharp spines projected left and right.

**Female.**— No specimen.

**Discussion.**— This specimen was probably collected at a light. Its terminalia characters are very distinctive. It is named after its collector.

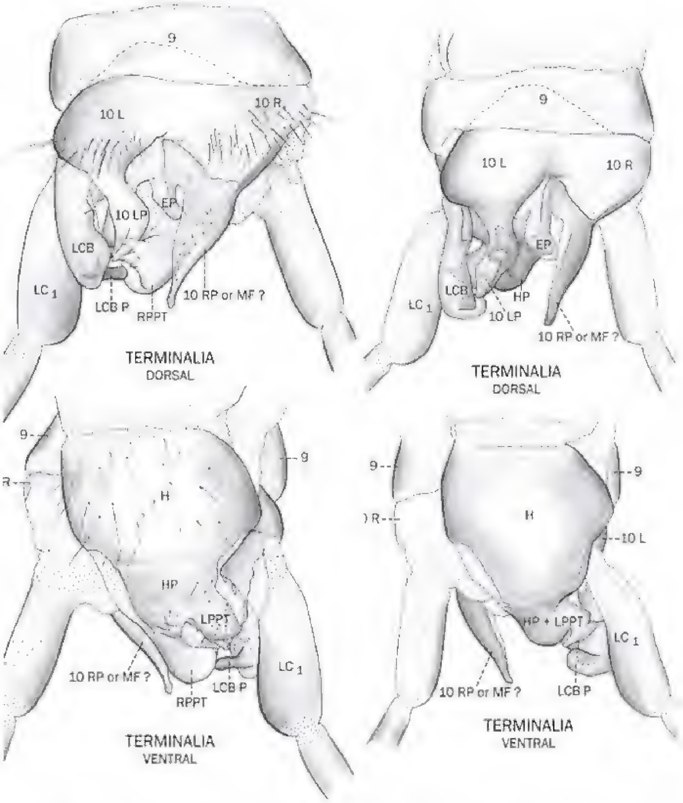

Figure 15. Important characters of holotypes of *Oligotoma burmana* Ross (left) and *Oligotoma ubicki* Ross (right). Both J.C. (see page 599 for abbreviations).

## *Bulbosembia* Ross, gen. nov.

Type species: *Bulbosembia thailandica* Ross, sp. nov., present designation.

**Distribution.**— Southeastern Asia.

**Diagnosis.**— Males small, body length about 8 mm. Always alate; uniformly pale tan to dark brown. Cranium varying from elongate-oval to broadly circular; eyes moderately large to very large, inflated. Antennae 15-segmented almost unicolorous, segments elongate, setae not especially long. Mandibles thin, usually short; submentum shield-like, moderately sclerotized, at times exceptionally small and narrow. Wings oligotomoid; MA forked at mid-wing. Hind basitarsi elongate, lacking a medial papilla. Terminalia basically oligotomoid with the following special characters: Left hermitergite (10 L) not lobed on dorsocaudal margin. Left process (10 LP) very short, but stout, twisted on edge; apex with a dorsally-rounded flange and a small, ventral, acute spur. Hypandrium process (HP) rounded apically, not turned upward or channeled at apex. Ejaculatory duct (ED) bordered internally by two filament-like sclerites which diverge basad. Left paraproct (LPPT) rudimentary, fused to side of HP; apex lacking a hook or "talon". Cerci two-segmented, left cercus-basipodite (LCB) represented only as a flange on outer base of cercus. Basal segment of left cercus very broad or bulbous apically, forming a rounded inner lobe; its inner-basal surface concave or channeled dorsally to serve as a recess for 10 LP when the cercus is pulled inward. Females without noteworthy generic characters. Uniformly tan to dark brown.

Discussion.— This distinct genus is most closely related to *Aposthonia* Krauss, but differs from this genus and all other oligotomids in the peculiar bulbous basal segment of the left cercus, which strongly resembles that of many species of *Embia* Latreille, but of course lacks echinulation. It differs in the other important characters mentioned above. The ejaculatory duct is unique in that it is bordered by a symmetrical, diverging pair of long, slender filaments. Such genital sclerotization, although present in some species, isn't as distinctly and symmetrically divided as in *Bulbosembia*.

Biology.— Colonies are located in bark crevices and under flakes of trees in damp tropical forests. They are scattered, difficult to find.

Component species.— In addition to the type species, described below, author has collected four additional species: one in Singapore's Bukit Timah forest reserve, two in hanging moss of cloud forest high in Malayan mountains (e.g., Gunong Batu Brinchang), and one from the 10,000 ft level on Mt Kinabalu, Sabah (Borneo).

***Bulbosembia thailandica*** **Ross, sp. nov.**
Figure 16.

Holotype.— Male, on slide, CAS. Thailand: waterfall, 20 mi SE of Chantaburi, 75 m, matured in culture 28-II-1963 (E.S. Ross).

Description.— Appearance: Small, slender; alate; medium brown with head darker brown. Color details (in alcohol): Cranium dark chocolate brown with very faint, pale maculation. Eyes blackish. Antennal segment 1 dark chestnut brown, 2 to 4 yellowish brown, 5 to 14 (the distal) medium brown. Mandibles dark amber; submentum also dark amber, clouded with dark brown basally. Prothorax and its legs dark brown; pterothorax basically creamy tan dorsally, brown laterally and ventrally. Mid and hind legs medium brown with pale trochanters. Pigmented bands of wings light brown; hyaline stripes narrow, sharply defined. Abdomen and its terminalia various shades of medium brown, membranous apex of hypandrium lobe whitish; apex

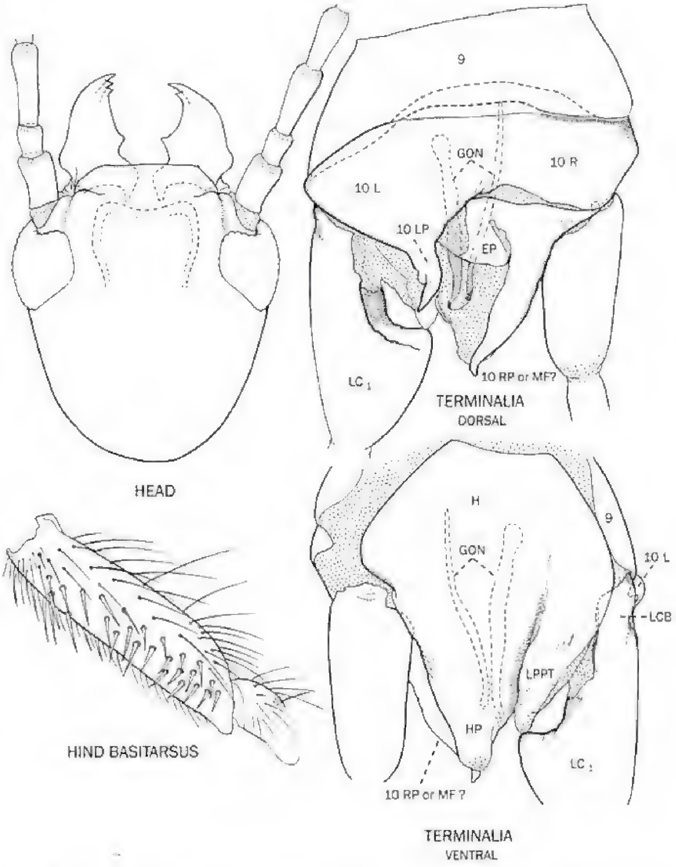

Figure 16. Important characters of holotype of *Bulbosembia thailandica* Ross. E.S.R. (see page 599 for abbreviations).

of left paraproct and ejaculatory duct filaments very dark brown, the latter visible through hypandrium's integument; apices of tergal processes golden amber. Dimensions (on slide): body length 6.5 mm; forewing length 4.5 mm, breadth 1.4 mm.

*Important anatomical characters*: As figured. Additional details will be treated when related species are described.

ALLOTYPE.— Female, in alcohol, CAS, from holotype's culture.

DESCRIPTION.— Slender, pale golden without contrasting pigmentation on portions of body or its appendages. Cranium bright gold anteriorly, with faint rusty tinge which also defines a basal maculation. Eyes black. Antennae 16-segmented, basally pale straw yellow, blending distad to yellowish tan. Prothoracic sclerites and legs yellowish tan mottled with rust. Remainder of insect pale yellowish tan with transparent sclerites appearing darker due to subcutaneous rusty gold tissue within; perigenital sternites not contrasting in pigmentation; cerci concolorous with abdomen. Without important anatomical characters. Body length 7.0 mm.

PARATYPES AND PARALLOTYPES.— Numerous topotypic adults reared in the holotype's culture to be deposited in major entomological museums.

DISCUSSION.— The type culture was stocked from small, inconspicuous colonies in crevices and flakes of tree bark in wet evergreen forest thinned for planting coffee. Colonies of *Ptilocerembia* Friederichs and *Eosembia* Ross were common in the same locality.

## *Lobosembia* Ross, gen. nov.

TYPE SPECIES: *Lobosembia mandibulata* Ross, sp. nov., present designation.

NAME BASIS.— Greek *lobos* in reference to an unusual dorsal lobe on each mandible of males.

DISTRIBUTION.— Northern Thailand: Mixed tropical forest. Probably also ranges into Laos, eastern Myanmar, and southwestern China.

DIAGNOSIS.— MALES: Large, body length averaging 15 mm; robust; alate; blackish except for a white band between pro and mesothorax, antennae entirely dark. Cranium broad, almost quadrate; clypeal margin sclerotic and inflexed, unicolorous. Eyes relatively small. Antennae 27-segmented; setae short, inconspicuous; apical segments not abruptly pale or white. Mandibles broad-based, then arcuated around labrum with an unusually elongate incisor lobe; the very short, dorsobasal carina usually conspicuously projected forward and outward as a lobe; submentum darkly sclerotized, inflexed sides project forward beyond anterior margin as incurved, knob-like lobes, anterior margin not otherwise inflexed. Wing venation oligotomoid, RS+MA forked at mid-length of wing; hyaline stripes very narrow, sharply defined; wing shape exceptionally broad; vannal area large, its basal edge narrowly folded beneath. Hind basitarsus elongate, without trace of a second papilla; plantar setae very dense, uniform in size and shape. Abdominal terminalia basically oligotomoid, with following unusual features: Left hemitergite (10 L) short, caudal margin not lobed, its process (10 LP) unusually small, straight, tapered caudad; hypandrium process (HP) arising broadly from a narrow hypandrium (H), is very long and somewhat twisted, its apex lying partially beneath inner lobe of basal segment of left cercus which it equals in length; apical third somewhat flared and dorsally sclerotized. Ejaculatory duct without trace of sclerotization. Left paraproct (LPPT) fused to HP. Left cercus-basipodite (LCB) represented only as a sclerotic flange fused to outer basal edge of left cercus, which is slender basally, then broadly expanded dorso-mesad as an angulate lobe which inserts into a mesodorsal depression on the inner apex of the left paraproct.

FEMALES: Large, robust, length averaging 17 mm; mostly chestnut brown anteriorly, abdomen and legs dark chocolate brown, thoracic intersegments creamy white; mid and hind coxae, trochanters, and tibial bases also creamy white; antennae and cerci entirely dark. Hind basitarsi with only one ventral papilla.

**Discussion.**— The lobed mandibles and that of the submentum and the composite left paraproct (HP+LPPT) especially distinguish this genus. The hypandrium lobe, and gallery formation distinguishes this genus from all others in the family, but it is probably most closely related to *Aposthonia* Krauss. Author also collected a possible second new species in northwestern Thailand, males of which have reduced mandibular lobes. The biological features described for the one species may be characteristic of all others in the genus.

### *Lobosembia mandibulata* Ross, sp. nov.

Figures 17–19.

**Holotype.**— Male, on slide, CAS. Thailand: East slope of Doi Suthep, near Chiang Mai, 560 m; matured in culture 15-IV-1963 (E.S. Ross).

**Description.**— Large, robust, broad-winged; blackish except for a white membranous intersomital band between pro- and mesothorax. Color details (in alcohol): Cranium dark chocolate brown, faintly clouded with mahogany brown between eyes and around anterior apophysial pits. Eyes gray. Antennae 27-segmented, segments 1 and 2 mahogany brown, all others medium brown blending to tan distad. Mandibles dark amber with dorso-basal lobes chocolate brown; submentum and palpi concolorous with cranium. Prothoracic sclerites and legs dark chocolate brown, lighter than cranium, poststernum golden brown; prothoracic membranes tinged brownish purple. Pterothoracic sclerites and membranes as in prothorax. Mid and hind legs similar to prothoracic legs in color except for yellowish brown tibial bases, coxae, and trochanters. Wings dark brown with very narrow hyaline stripes, whole surface with iridescent violet luster. Abdominal coloration similar to that of thorax except for darker terminalia which have the epiproct sclerite and its left process amber yellow; membranes white on inner side of right process and around aperture of ejaculatory duct, other membranes purplish; distal segments of cerci mahogany brown. Dimensions (on slide): body length 16.0 mm; forewing length 8.5 mm, breadth 2.5 mm.

*Important anatomical characters.*— As figured and noted in generic Diagnosis.

**Allotype.**— Female, in alcohol, CAS. From holotype's culture.

**Description.**— Large, robust; mostly chestnut brown anteriorly with white membranous band between each thoracic somite; abdomen and legs dark chocolate brown. Color details: Crani-

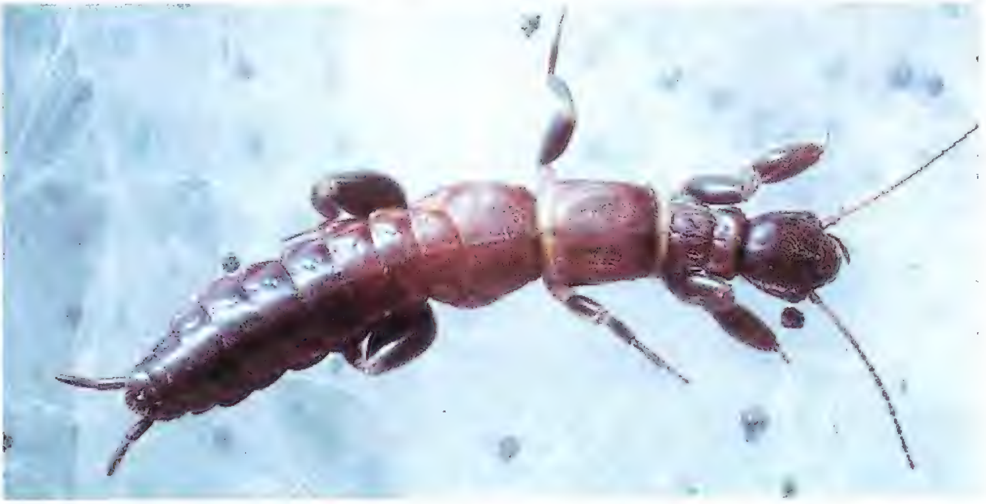

Figure 17. Adult female of *Lobosembia mandibulata* Ross, sp. nov. From 11 km NW of Fang, near Chiang Dao (cave), Chiang Mai Prov., Thailand. Matured in culture II-1980 (E.S. Ross). E.S.R.

um basically dull, dark chocolate brown, blending to dull golden brown in a broad transverse arc between eyes, and ventrally. Eyes grayish black. Antennae 27-segmented; segments 1 and 2 chestnut brown, 3 and 4 yellowish tan, others becoming dark brown to apex. Prothoracic sclerites clouded, dark chestnut brown, membranes purple. Forelegs dark chocolate brown with femorotibial joint creamy white. Acrotergites and associated lobes and membranes creamy white resulting in a two-banded appearance. Meso and meta-thoracic scuta "granular", chestnut brown; pleurities and most of sternites chocolate brown; basisterna largely yellowish brown; mid and hind legs chocolate brown except for creamy white coxae, trocanters, and femorotibial joints. Basal abdominal tergites at first concolorous with metathoracic scutum, others becoming very dark chocolate brown caudad; sternites 1 and 2 creamy white, others dark chestnut brown, but with sclerotic portions of paragenital sternites dark chocolate brown; abdominal membranes purple. Cerci chocolate brown with purple membranes. Body length 18 mm. Without anatomical characters for species definition.

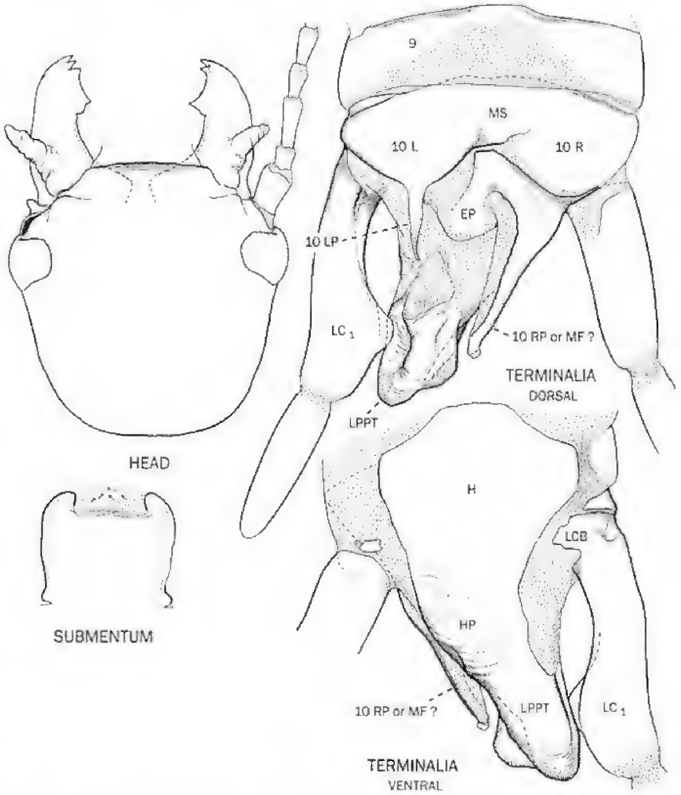

FIGURE 18. Important characters of holotype of *Lobosembia mandibulata* Ross. E.S.R. (see page 599 for abbreviations).

**PARATYPES AND PARALLOTYPES.**— Series of topotypic adults reared in holotype's culture; to be deposited in CAS, USNM, BMNH, and other major museums.

**BIOLOGY.**— Colonies are most often spun on the bark surfaces of slender trees in open hardwood forest on sunny ridges at about the 560-meter level of the lower slopes of mountains, such as Thailand's Doi Suthep. Such forests have a grass under story and are subject to seasonal drought and fires. Colonies have a peculiar formation; each is composed of a single long gallery of clean silk without lateral branches. When first encountered during the wet season of mid-July, each colony contained only a single female and her egg mass, which was about 10 mm in diameter, and contained a single layer of about fifty eggs embedded in a matrix of mas-

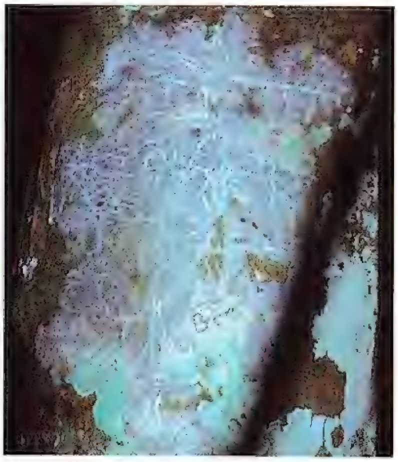

FIGURE 19. Large colony of *Lobosembia mandibulata* Ross, sp. nov. On a tree trunk 11 km NW of Fang, near Chiang Dao (cave), Chiang Mai Prov., Thailand. XI-1978 (E.S. Ross). Silk galleries produced by brood of a single parent female. Note silk is not covered with pulverized bark or feces. E.S.R.

ticated bark fragments or fecal pellets. The entire layer was covered with a sheet of silk. No adult males were encountered in the field, although some of the females were almost mature. Broods of field-collected females and eggs matured between mid April and early June the following year. Attempts to rear another cycle in the laboratory failed. The colonies might possibly have a much different appearance as the broods develop if they had remained together. No prior-season remnants of large labyrinths were found; author suspects that nymphs disperse and that each individual matures in a separate gallery.

ADDITIONAL RECORDS.— All Thailand; collected by E.S. Ross. Numerous topotypic cultured specimens from various locations on E slope of Doi Suthep (above Chiang Mai); 400–600 m in elevation. Most males matured during April. Large cultured series from Samaung, 23 mi S of Chiang Mai, 900 m, on limbs of a freshly cut tree. Some males have much shorter mandibular lobes, but their terminalia are typical. Large cultured series from 11 km NW of Fang, Chiang Dao (cave), Chiang Mai Prov., colonies on tree trunks, adults matured XI-1978.

## ACKNOWLEDGEMENTS

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## EXPLANATION OF SYMBOLS

9 = ninth abdominal tergite; 10L and 10R = hemitergites of tenth segment, 10 LP and 10 RP = processes of these hemitergites; MS = medial sclerite of 10; EP = epiproct (segment 11); H = hypandrium (sternite 9); HP = process of H; LPPT and RPPT = left and right paraprocts; LCB and RCB = left and right cercus-basipodites; LC 1+2 = composite left cercus; GON = gonopophysis (?) –internal sclerotic "rods" bordering the apex of the ejaculatory duct; LPPT-P = process of left paraproct.

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# Geographic Variation in a Cardinalfish, *Apogon dianthus* (Teleostei: Apogonidae)

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**The description of *Apogon dianthus*, previously known from a single specimen from Palau, is expanded based on new material from Fiji, Papua New Guinea, Indonesia, the Philippines, and the Comoros. Specimens from Palau and the Comoros differ from those in other areas by having fewer gill rakers, a deeper caudal peduncle, and a shorter spine in the second dorsal fin.**

*Apogon dianthus* was described by Fraser and Randall (2002) from a single specimen taken at Palau in the western Pacific Ocean. Since that time it has not been recorded from any other locality, nor have any additional specimens from Palau been reported. Greenfield and Randall (2004) described a new species from Easter Island, *Apogon rubrifuscus*, and said that it belonged to a group of species they referred to as "*talboti* look-alikes." The *talboti* look-alikes have two predorsal (supraneural) bones instead of three as in the *A. talboti* group, and 12 pectoral-fin rays rather than the 13 in *A. talboti*. There also are differences in the membranous flap at the lower corner and along the lower margin of the preoperculum as illustrated in Greenfield and Randall (2004, fig. 4; see also Fig. 5 [here]). Greenfield and Randall (2004) commented "Because of this similarity, a number of specimens reside on museum shelves identified as *A. talboti*, but they are not." *Apogon dianthus* is a member of the *talboti* look-alike group.

While conducting a survey of the marine fishes of Fiji, I collected a number of specimens of a species in the *talboti* look-alike group, and initially believed that it was an undescribed species; however, after reviewing the description of the single specimen of *A. dianthus* from Palau, I realized that it was very similar, although differing in several characters. In searching other collections, additional specimens similar to those in Fiji were discovered. A name often used for these *talboti* look-alike specimens was *A. unicolor* Steindachner & Doderlein, a member of the *A. talboti* group.

One additional specimen of *A. dianthus* from Palau was located at the FMNH, and ROM specimens very similar to those from Palau were found from the Comoros. In addition, specimens similar to the Fiji population were found from Papua New Guinea, Indonesia, and the Philippines.

The purpose of this paper is to provide an expanded description of *A. dianthus* that previously had been based on a single specimen, and to demonstrate the population differences between specimens from Fiji, Papua New Guinea, Indonesia, and the Philippines from those in Palau and the Comoros.

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## Materials and Methods

All counts and measurements follow Hubbs and Lagler (1964) except that the last two fin rays of the dorsal and anal fins are not counted as one unless it is clear that they are joined at the base, and the caudal-peduncle length is a straight line rather than an oblique measurement. Measurements were made to the nearest 0.1 mm using dial calipers and are expressed as percentages of standard length (SL). The length of fin spines was measured by placing one end of the caliper tip at the base of the spine pushed against the posterior base of anterior spine and the other caliper tip at the spine tip. Gill-raker counts include rudiments. The holotype, which is in poor condition, was remeasured to standardize comparisons made with other specimens. Measurements in Table 2 for Palau and the Comoros are based on two specimens from Palau and five from the Comoros; those for Fiji specimens are based on five individuals. In Table 2, the ranges are followed by the mean values. Only measurements of caudal-peduncle depth and the length of the spine of the second dorsal fin were taken on specimens from Papua New Guinea, the Philippines, and Indonesia and from additional specimens from Fiji and the Comoros. Institutional abbreviations are as given in Leviton et al. (1985).

## Species Description

### *Apogon dianthus* Fraser and Randall (2002)

**Material Examined.**—Palau and Comoros: **Palau**: Holotype-BPBM 9360, 48.6 mm SL; FMNH 117466, 40.2 mm. **Comoros**: ROM 59135, 42.8 mm; ROM 59136, 39.6 mm; ROM 59137, 37.6 mm; ROM 59138, 32.2 mm; ROM 59139, 43.1 mm; ROM 59140, 44.9 mm; CAS 35491, (2, 47.3–47.6 mm). Fiji, Papua New Guinea, Indonesia, and Philippines: **Fiji**: CAS 225484, 44.6 mm; CAS 225485, 43.3 mm; CAS 225486, (2, 25.2–38.7 mm); CAS 225487, 28.3 mm; CAS 225488, (2, 28.8–43.2 mm); CAS 225489, 45.2 mm; CAS 225490, 39.2 mm; CAS 225491, 40.4 mm; CAS 225492, (2, 39.3–39.5 mm); CAS 225493, (4, 29.3–38.6 mm); CAS 225494, (7, 39.2–47.4 mm); CAS 225495, 40.6 mm; ROM 43075, (3, 34.4–41.0 mm); ROM 43076, (3, 42.4–49.2 mm); ROM 43077, 23.6 mm; ROM 43078, 39.2 mm; ROM 43079, (2, 38.4–39.0 mm); ROM 43081, 39.0 mm. **Papua New Guinea**: USNM 262415, (5, 28.2–40.3 mm); BPBM 32552, 39.4 mm. **Indonesia**: USNM 262711, 49.9 mm. **Philippines**: USNM 262237, (3, 31.9–42.5 mm); ROM 54038, 47.5 mm.; ROM 54039, 48.5 mm.

**Description.**— Dorsal-fin elements VI-I,8; anal-fin elements II,9; pectoral-fin rays 12–13 (only two out of 44 had 13); pored lateral-line scales 22–24, usually 23 plus one or two more past hypural plate; predorsal scales six; scales above lateral line to origin of first dorsal fin one; scales below lateral line to origin of anal fin six; circumpeduncular scales 12; gill raker counts vary by location (Table 1).

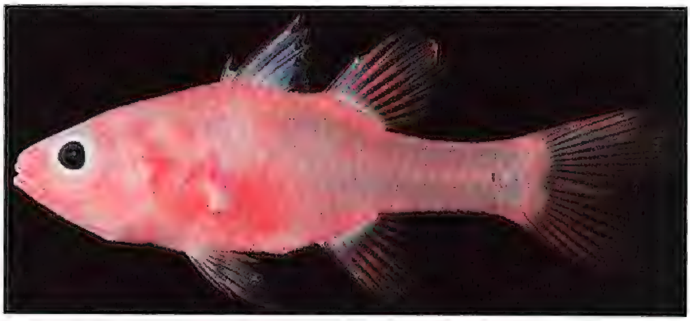

Figure 1. Holotype of *Apogon dianthus*, BPBM 9360 from Palau, 48.6 mm SL. Photograph by J.E. Randall.

Color of fresh specimens.— A photograph of the holotype of *Apogon dianthus* is presented in Figure 1. Photographs of specimens from Fiji (Fig. 2), and the Comoros (Fig. 3) also are shown.

**Variation.**— The range and modal number of gill rakers differ among specimens from Palau and the Comoros versus those from Fiji, Papua New Guinea, Indonesia, and the

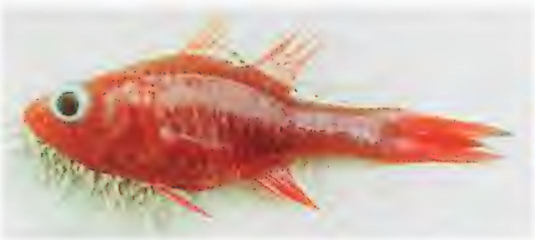

FIGURE 2. *Apogon dianthus* from Fiji, CAS 225484, 44.6 mm SL.

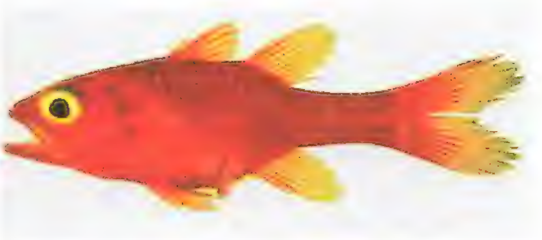

FIGURE 3. *Apogon dianthus* from the Comoros, ROM 59135, 42.8 mm SL. Photograph by R.W. Winterbottom.

Philippines, being higher in the latter group (Table 1). Two body proportions also differ between these two groups. The depth of the caudal peduncle is less in the Fiji group and the length of the spine in the second dorsal fin is greater (Table 2). The length of the second dorsal-fin spine divided into the caudal-peduncle depth for the two groups is plotted in Fig. 4. No significant differences in color were noted.

**Remarks.**—*Apogon dianthus* belongs to a group of *Apogon* species in the subgenus *Apogon* with two predorsal (supraneural) bones and a membranous flap at the lower corner and along the ventral margin of the preopecle

TABLE 1. Gill-raker counts of *Apogon dianthus* from various locations.

| *Location* | *Upper* | | *Lower* | | | | |
|---|---|---|---|---|---|---|---|
| | 4 | 5 | 14 | 15 | 16 | 17 | 18 |
| *Palau* | | 2 | | 2 | | | |
| *Comoros* | 4 | 5 | 3 | 4 | 2 | | |
| *Fiji* | | 34 | | 1 | 25 | 7 | 1 |
| *Papua New Guinea* | | 6 | | 1 | 5 | | |
| *Indonesia* | | 1 | | | 1 | | |
| *Philippines* | | 4 | | 1 | 3 | | |

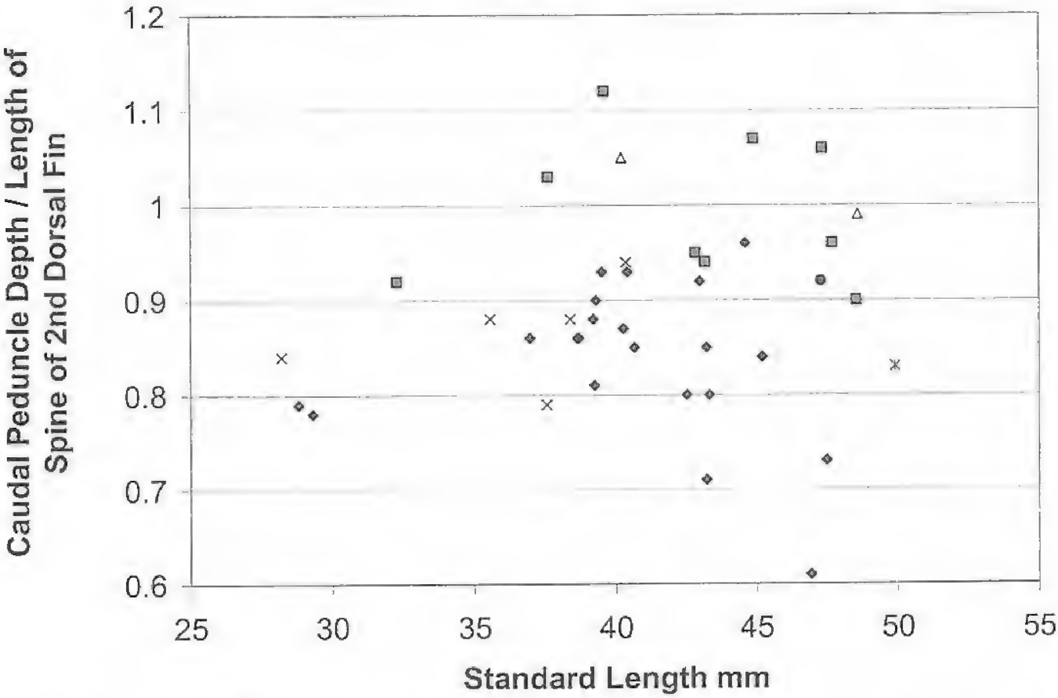

FIGURE 4. Standard length versus caudal-peduncle depth divided by length of spine of second dorsal fin for various *Apogon dianthus* populations. Solid diamonds – Fiji; solid squares – Comoros; X – Papua New Guinea; open triangles – Palau; solid circle – Philippines; asterisk – Indonesia.

TABLE 2. Body measurements of *Apogon dianthus* from various locations as percentage of standard length. Ranges are followed by means.

| | *Palau-Holotype* | *Palau-FMNH* | *Comoros* | *Fiji* |
|---|---|---|---|---|
| Standard length | 48.6 | 40.2 | 43.1–48.5 | 43.3–47.4 |
| Head length | 36.9 | 37.3 | 36.3–38.6; 37.7 | 37.6–40.4; 40.0 |
| Eye diameter | 13.2 | 11.9 | 11.7–13.5; 12.8 | 12.0–13.5; 12.6 |
| Snout length | 7.9 | 6.2 | 6.1–7.3; 6.7 | 5.0–8.1; 6.7 |
| Bony interorbital width | 6.7 | 6.2 | 6.9–8.0; 7.3 | 6.0–6.9; 6.3 |
| Upper jaw length | 19.9 | 20.1 | 19.5–20.7; 20.3 | 19.8–21.7; 21.1 |
| Body depth | 27.8 | 33.6 | 23.2–35.0; 31.8 | 32.4–35.2; 33.5 |
| Body width | 16.5 | 18.9 | 19.3–22.0; 20.6 | 18.0–20.0; 19.2 |
| Predorsal length | 41.9 | 38.3 | 38.7–42.6; 41.4 | 39.1–40.7; 40.0 |
| Preanal length | 60 | 60.1 | 57.6–61.3; 59.8 | 56.2–60.0; 58.5 |
| Caudal-peduncle depth | 13.7 | 13.7 | 12.9–14.5; 13.5 | 11.0–14.8; 12.6 |
| Caudal-peduncle length | 28 | 30.1 | 23.3–33.6; 28.9 | 27.0–39.2; 31.2 |
| Prepectoral length | 40.2 | 35.8 | 35.5–40.4; 37.7 | 36.9–39.9; 38.3 |
| Prepelvic length | 32.1 | 34.2 | 30.6–39.0; 35.0 | 33.2–35.6; 34.8 |
| 1st dorsal-fin base | 17.7 | 16.8 | 17.0–17.9; 17.5 | 14.2–16.6; 15.9 |
| 2nd dorsal-fin base | 14.8 | 12.9 | 13.0–14.8; 13.9 | 12.8–14.7; 13.9 |
| Anal-fin base | 12.2 | 13.6 | 12.6–14.5; 13.7 | 12.0–15.3; 13.2 |
| 1st dorsal-fin spine | 6.6 | 6.5 | 7.0–8.0; 7.4 | 6.2–7.9; 7.2 |
| 2nd dorsal-fin spine | 20.8 | 19.1 | 17.1–22.1; 19.9 | 19.7–23.3; 21.3 |
| 3rd dorsal-fin spine | 16.9 | 16.2 | 16.1–18.7; 17.4 | 17.5–19.2; 18.6 |
| Spine 2nd dorsal fin | 13.9 | 13.1 | 12.1–14.7; 13.7 | 15.4–18.0; 16.1 |
| Longest dorsal ray | ----- | 24.6 | 23.6–27.5; 25.3 | 24.4–30.2; 26.9 |
| 1st anal spine | 4.4 | 3.5 | 3.1–4.4; 3.6 | 3.5–5.7; 4.3 |
| 2nd anal spine | 15.6 | 14.8 | 12.2–16.8; 14.5 | 14.6–16.5; 15.4 |
| Longest anal ray | ----- | 25.6 | 24.7-28.4; 26.5 | 24.8-26.4; 25.6 |
| Caudal-fin length | ----- | ----- | 34.0–40.2; 37.1 | 35.5–38.6; 36.9 |
| Caudal-fin concavity | ----- | ----- | 12.4–18.2; 15.3 | 13.4–17.7; 16.1 |
| Pectoral-fin length | ----- | 29.1 | 29.6–41.4; 32.5 | 29.3–44.3; 34.4 |
| Pelvic-fin length | ----- | 25.9 | 25.4–25.7; 25.6 | 25.3–27.5; 26.1 |

(Fig. 5). The other members of this group include *A. deetsie* Randall (1998), *A. caudicinctus* Randall and Smith (1988), and *A. rubrifuscus* Greenfield and Randall (2004). Although Greenfield and Randall (2004) distinguished *A. rubrifuscus* from *A. deetsie* and *A. caudicinctus*, they failed to differentiate it from *A. dianthus* in their comparisons. *Apogon dianthus* differs from *A. rubrifuscus* by having a much deeper caudal peduncle (11 % SL or greater, means 12.6 and 13.5, Table 2) versus 10% SL. *Apogon rubrifuscus* also is a much larger species (101.5 mm SL), whereas the largest specimen of *A. dianthus* I have seen is 48.6 mm SL.

Although there are differences between the specimens from Fiji and other South Pacific areas and those from Palau and the Comoros, until DNA samples can be obtained, I believe that it is best to be conservative and treat the Fiji specimens as *A. dianthus*. Two specimens from Fiji were preserved in ETOH, from CAS 225494 and CAS 225489, and are now cataloged in the University of Kansas tissue collection as KU 40246 and KU 40247, awaiting comparative DNA samples from Palau.

If, in fact, the specimens from Palau and the Comoros are the same, then this is another example of two widely disjunct populations such as that shown for *Blenniella gibbifrons* by Springer and

Williams (1994). In the current case, the intervening populations are from off the Pacific plate, reaching from Fiji into the Indo-Australian Archipelago and not an endemic found only in the archipelago, as is the case for *B. gibbifrons*, where *B. bilitonensis* separates the two *B. gibbifrons* populations.

The specimens from Fiji were taken most often from dropoff walls or deep spur and groove habitats, usually greater than 15 m in depth. The range of capture was 6.7–27 m, having been taken once in a 6.7 m coral-rubble habitat. Those from the Comoros also were from dropoff habitats at depths of 12–27 m.

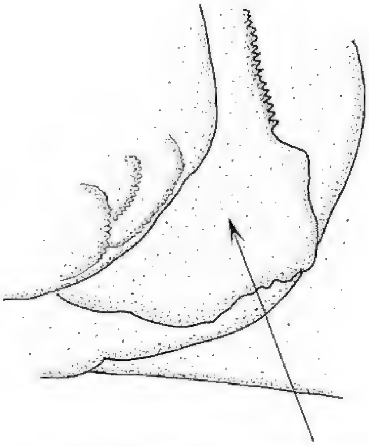

FIGURE 5. Preopercle and membranous flap of *Apogon dianthus*, CAS 225488, 43.2 mm SL.

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Compiled by Alan E. Leviton and Michele L. Aldrich

(New taxa are in **boldface** type)

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